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ABSTRACT

This guide is intended for use by individuals preparing for a career in commercial and residential irrigation. The materials included are geared toward students who have had some experience in the irrigation business; they are intended to be presented in 10 six-hour sessions. The first two sections deal with using this guide and preparing for the licensed irrigator's exam. The following topics are covered in the individual lessons: irrigation then and now; procedures for controlling water flow (water meters and cross connections, valves, controllers and electrical wiring); methods of controlling water placement (piping and sprinkler types and nozzles); layout and design (design basics, basics of hydraulics, and procedures for developing a design and checking it mathematically); drip irrigation; and irrigation considerations. Each lesson includes an overview, definition(s), instructional text, and a subject review exercise. Drawing and laboratory exercises are also provided. Appendixes contain the text of Texas's Licensed Irrigators Act and Permanent Rules for Irrigators, examples of local codes, common terminology of the turf irrigation industry, and an index. (MN)

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IRRIGATION SYSTEMS

Student's Guide

AMARILLO JUNIOR COLLEGE DISTRICT
1929

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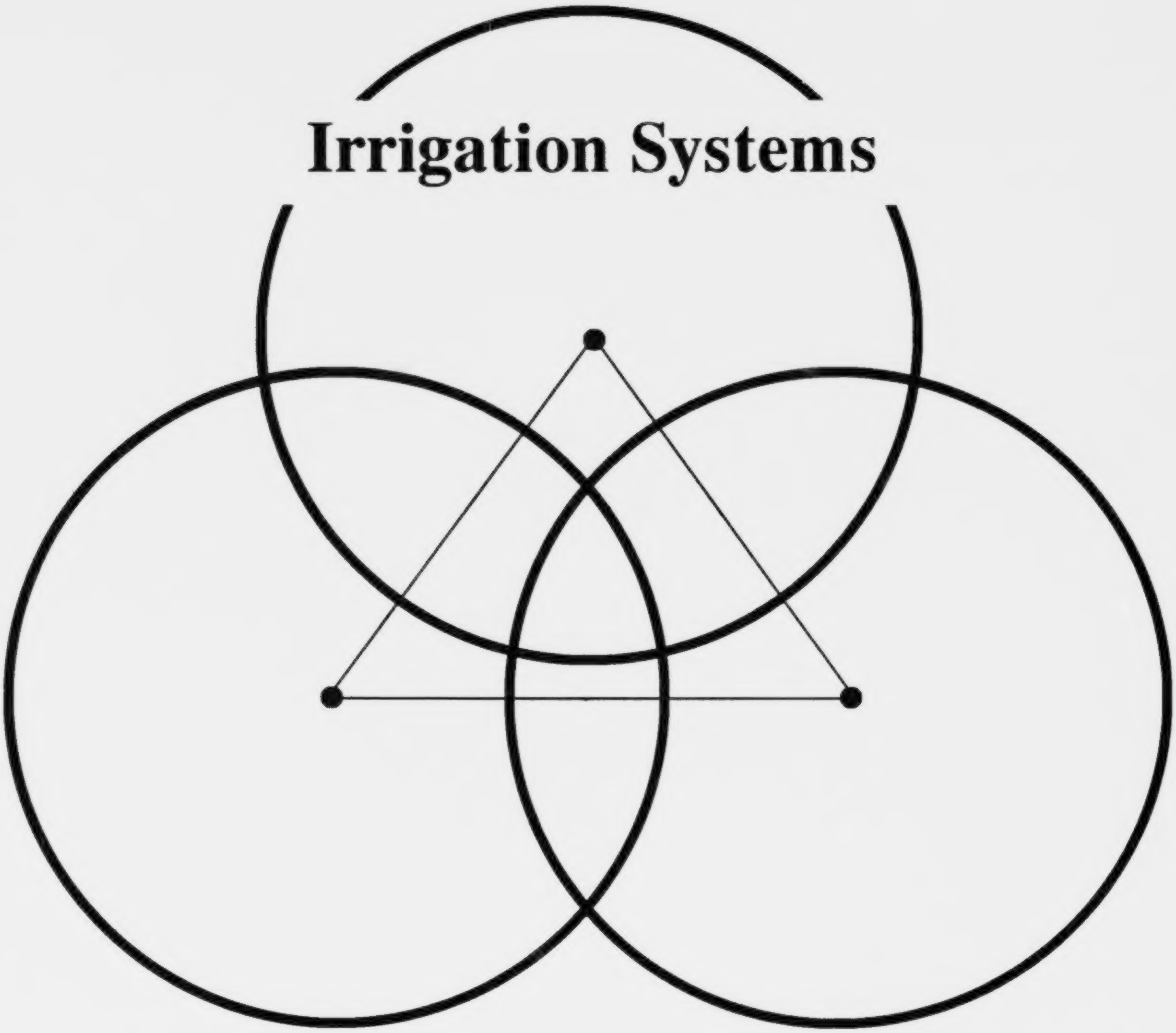
Irrigation Systems



Design and Installation

Student's Guide

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1. Using This Guide

Overview

This section provides orientation information, such as how the course is structured, what materials you need, and how to prepare for the classroom.

Read this section completely before attempting to use the rest of this Guide.

Purpose of the Irrigation Systems course

This course helps prepare a student for a career in commercial and residential irrigation. In the process, the course helps prepare a student to take the licensing examinations given by the Texas Board of Irrigators.

Purpose of this guide and intended audience

This guide contains a structured method for presenting the design and installation of irrigation sprinkler systems. *This guide is not a textbook on irrigation systems.* Rather, it allows you to learn about irrigation technology, in a systematic manner, in classroom and laboratory settings.

This guide is intended for the student who has some work experience in the irrigation business.

How the course is structured

The Irrigation Systems course is a 60 clock hour course that includes 4 laboratory exercises and 4 drawing exercises.

To simplify explanations, this guide discusses the course as if you will attend in 10, six-hour sessions. The sessions will meet once a week.

Textbook for the course

The textbook for the course is the *ABC's of Lawn Sprinkler Systems* prepared by the staff of Irrigation Technical Services under the direction of A. C. Sarsfield.

In addition to the *ABC's*, you may want to purchase a copy of the *Turf Irrigation Manual, The Complete Guide to Turf and Landscape Sprinkler Systems*, by James A. Watkins. This book is not required for the course, but you may wish to add it to your own collection of reference books.

Student's Guide

The Student's Guide supplements the course textbook and helps round out the explanations of certain subjects.

The Student's Guide uses a two column format. The left hand column contains descriptive information about the paragraphs in the right hand column. The descriptive information helps you move quickly through the pages and pick out key ideas.

The lines of descriptive information are called callouts.

Sections in the Guide

As you can see from the table of contents, this guide is divided into 12 sections.

All of the sections dealing with irrigation systems are similarly organized. They present the material in narrative form and usually conclude with a subject review.

The subject reviews usually contain 24 questions: 8 fill in the blank, 8 true or false, and 8 multiple choice.

Section 1 contains information to help you get oriented and organized.

Section 2 tells you how to prepare for the Licensed Irrigators examination. The section contains samples of the types of letters that you will receive from the state, the type of instructions, and tips on taking the examination.

Section 3 is a general introduction to irrigation.

Sections 4 through 8 contain the heart of the subject matter. The subjects are generally organized in a from-the-meter-to-the-house approach. That is, the discussion of irrigation systems begins at the water meter and works its way toward the dwelling.

Section 8 is designed to be taught by persons other than the instructor, such as local code inspectors, local landscapers, etc. If you know of local persons who would speak on an irrigation subject, please inform the instructor.

The last 3 sections contain reference materials to supplement the course.

Labs and drawing exercises

Four laboratories allow you to physically participate in the learning process, such as dismantling components and practicing solvent welding. In addition, you will practice the layout and design of sprinkler systems. The labs and the design exercises are discussed in the tabbed section "Labs and Exercises."

Overview of the sections by weeks

The following graphic representation shows what material you will cover during which week.

Week 1

1. Using This Guide

   Written equivalent of a handshake, a hello, and a "let me show you around."

2. Preparing For The LI Exam

   General information about the Licensed Irrigators Exam.

3. Irrigation - Then and Now

   Irrigation history
   Laws
   TBI act
   Ethics and practice
   Evolution of products
   Terms and definitions

Week 2
(plus Lab 1)

4. Controlling Water Flow

   Water meters
   Cross connection
   Backflow prevention

Week 3

Valves
Types, uses, etc.

Controllers and electrical wiring

Week 4 (plus Lab 2)	5. Controlling Water Placement Piping Types, uses, schedules, etc. Connecting pipe Solvent welding and soldering Sprinkler types and nozzles Precipitation and application rates 6. Layout and Design Basics of hydraulics Drawing exercise 1
Week 5	Design and plot plans Design hydraulics Drawing exercise 2
Week 6 (plus Lab 3)	7. Drip Irrigation Drip and micro irrigation Percolation Drawing exercise 3
Week 7	8. Irrigation Considerations Codes and ordinances Application enforcement Landscape design Beautification Efficiency of water use

9. Labs and Exercises

Week 2	Lab #1 Show and tell of backflow prevention devices
Week 4	Lab #2 Show and tell of solvent welding, soldering, types of pipe Drawing Exercise #1
Week 5	Drawing Exercise #2
Week 6	Lab #3 Show and tell of drip irrigation products Begin Drawing Exercise #3
Week 7	Complete Drawing Exercise #3
Week 8	Lab #4 Show and tell of irrigation equipment (trenchers, etc.) Drawing Exercise #4
Week 9	Practice test, LI Exam design part s
Week 10	Practice test, LI Exam written part

Materials you need for the course

You will need the following materials for this course:

The *ABC's of Lawn Sprinkler Systems* (available from the instructor)
1-1/2 inch ring binder (D-ring type is superior to round-ring, but costs more)
12 do-it-yourself tab dividers
Pencils, #2 with erasers
Paper, ruled
Tracing paper or onion skin paper (small package)
Calculator (hand-held or desktop)
Graph paper, 10 squares per inch
Ruler, 10 scale
Drafting compass
Drafting triangles
Eraser
Erasing shield
Drafting board, at least 18" X 24"

Additional materials you may wish to have

Drafting templates
Cassette tape recorder to record lectures
Cassette tapes
Extension cord
Reference books and magazines
Examples of interesting irrigation products (very old or very new items, oddball items, self-made items, etc.)

Additional materials you may wish to have

You may obtain most of the materials at an office supply store, college book store, or a general merchandise store. You do not need top-of-the-line drafting supplies for this course. Such supplies are very expensive and are unnecessary for the type of design work that this course requires.

Items supplied to you

The following is a list of the items that you will receive from the instructor for the course.

1 copy of the Student's Guide

1 copy of the *ABC's of Lawn Sprinkler Systems*

Steps to complete at the start of the course

Make sure that you complete the following activities before the course begins:

1. Assist the college is advertising the course and obtaining students. Notify likely candidates about the course.

2. Locate the classrooms and familiarize yourself with the area.

3. Begin gathering scrap pieces of tubular goods, such as PVC, PE, ABC, and copper piper. The pieces can be 12 inches or shorter. Also gather any samples of solvents and cleaners. You will use these items in one of the labs. Plumbing contractors and plumbing supply houses often will give such items away since they are scraps or free samples.

Steps to complete for each class session

Make sure that you complete the following activities for each class session:

1. *Complete the reading assignments and out-of-class work and come prepared to contribute to the class discussions.*

   The importance of completing the reading assignments and out-of-class work cannot be over emphasized. The extent to which you benefit from this course depends mostly on you. If you are unwilling to read and do the homework, then you will benefit little from the course.

2. Be there on time.

Steps to complete after the course is over

Make sure that you complete the following activities after the course is over:

1. Evaluate your feelings about the course and the success of it.
2. Return all materials to the college that belong to the college. This includes the samples of irrigation products used in the labs.
3. Apply what you have learned, share what you know, and help make the irrigation profession a success.

2. Preparing For The LI Exam

Overview

This section discusses the Licensed Irrigator's Examination administered by the Texas Board of Irrigators (TBI). This section tells you how to apply for and prepare for the exam, and shows you examples of various correspondence that you will receive from the TBI.

The LI Exam defined

Texas state law requires that irrigators be licensed by the state to legally install and maintain sprinkler systems. The licensing is to protect our potable water supplies. The Licensed Irrigator's Examination is a method of determining who gets licensed. The exam is a five-part test given several times a year in Austin. The purpose of the exam is to ensure that only those irrigators with a certain level of knowledge and competency obtain licensure.

To pass the exam, you must score at least a 70 on each of the five sections.

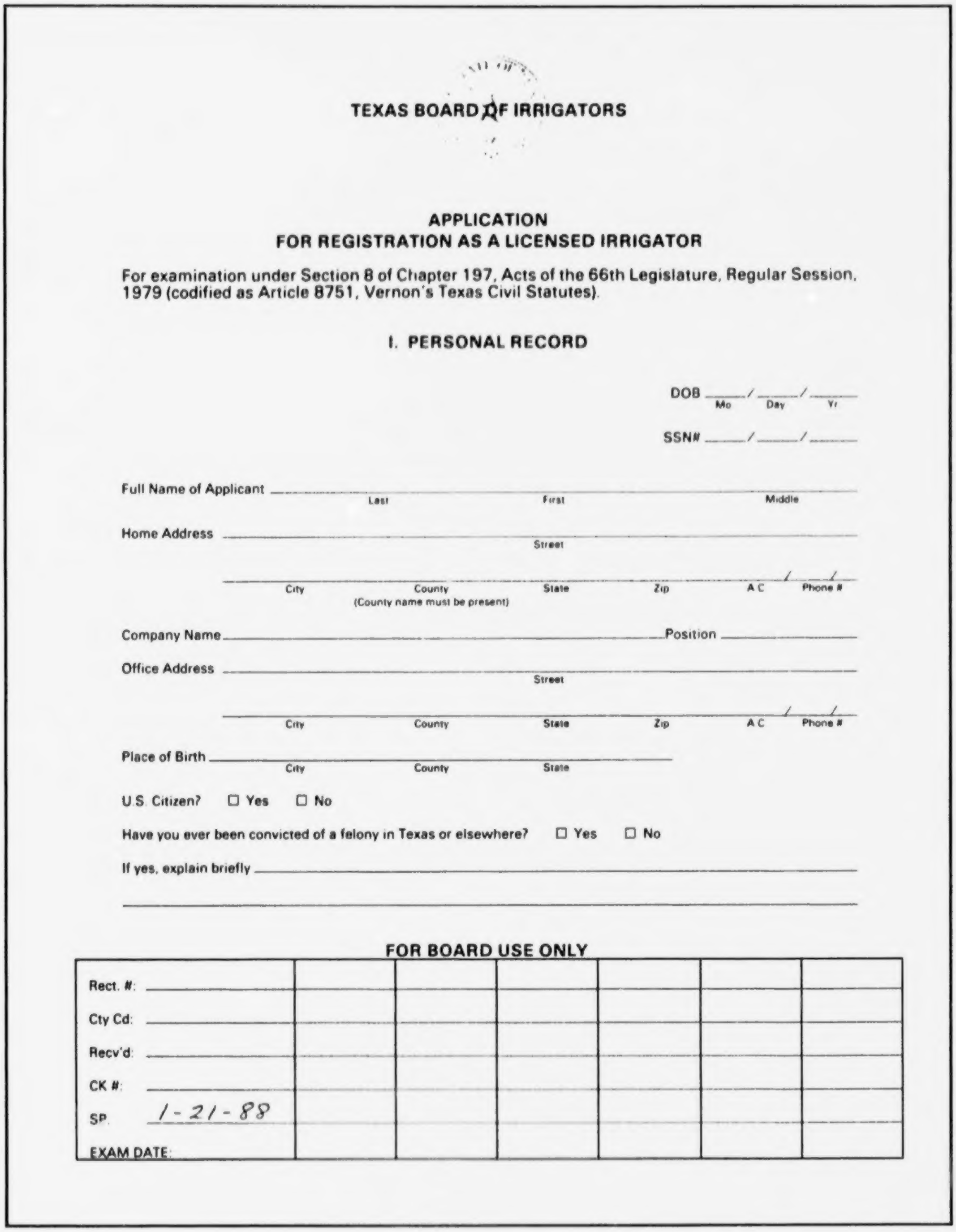
Applying for the LI Exam

You must submit an application to become a licensed irrigator. It is strongly suggested that you request the application at least two months prior to the test day. You must return the completed application at least one month prior to the test day.

To request the application, contact the Texas Board of Irrigators and ask for the "Application For Registration As A Licensed Irrigator." You may write or telephone:

Texas Board of Irrigators
P.O. Box 12337
Austin, Texas 78711
(512) 463-7990

The Texas Board of Irrigators will send you some general information about the exam and the application. The next six pages show examples of what you will receive.



TEXAS BOARD OF IRRIGATORS

APPLICATION
FOR REGISTRATION AS A LICENSED IRRIGATOR

For examination under Section 8 of Chapter 197, Acts of the 66th Legislature, Regular Session, 1979 (codified as Article 8751, Vernon's Texas Civil Statutes).

I. PERSONAL RECORD

DOB ____/____/____ Mo Day Yr

SSN# ____/____/____

Full Name of Applicant ____________ Last First Middle

Home Address ____________ Street

____________ City County (County name must be present) State Zip A C / Phone # /

Company Name ____________ Position ____________

Office Address ____________ Street

____________ City County State Zip A C / Phone # /

Place of Birth ____________ City County State

U.S. Citizen? ☐ Yes ☐ No

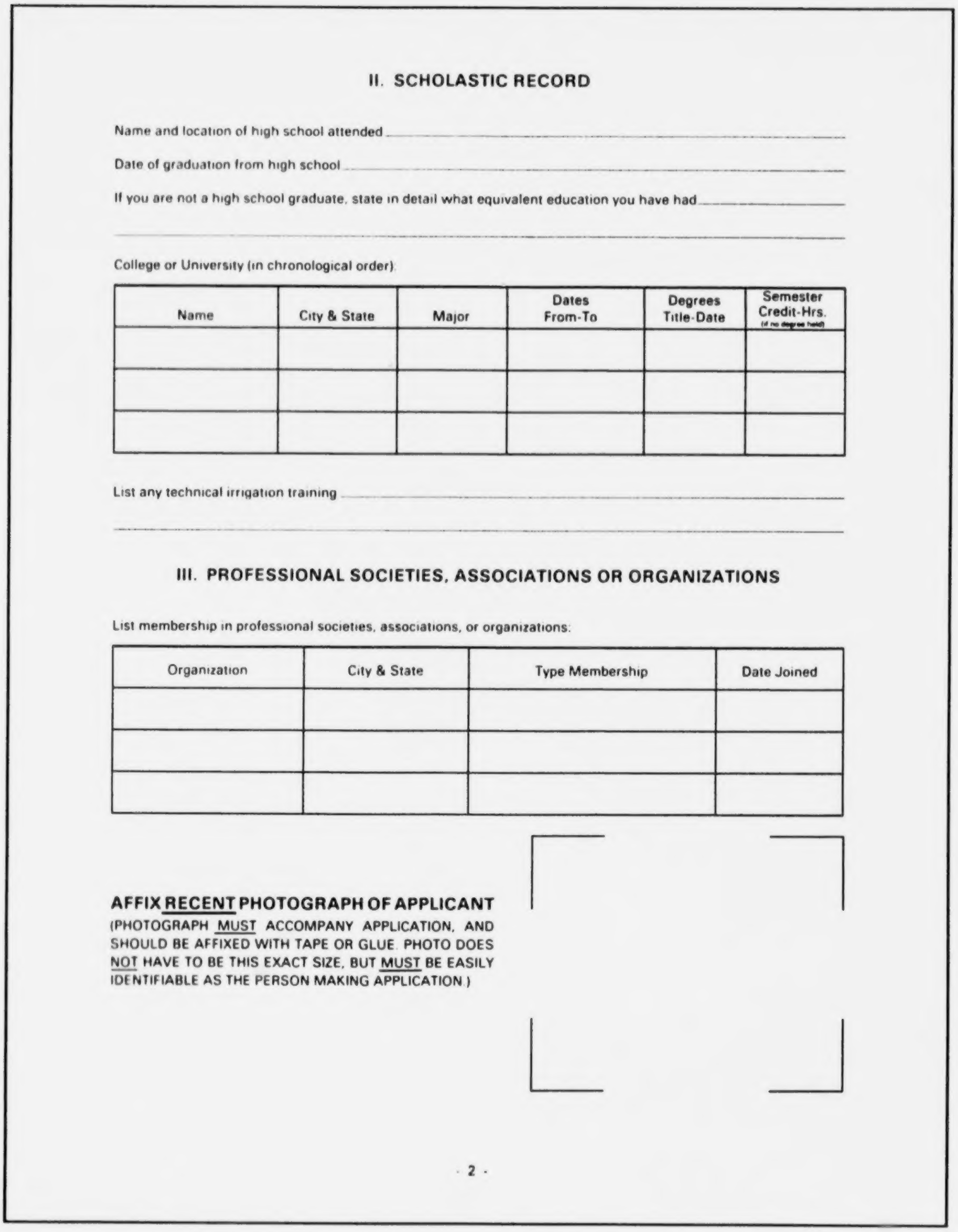
Have you ever been convicted of a felony in Texas or elsewhere? ☐ Yes ☐ No

If yes, explain briefly ____________

____

FOR BOARD USE ONLY

Rect. #:						
Cty Cd:						
Recv'd:						
CK #:						
SP. 1-21-88						
EXAM DATE:						



II. SCHOLASTIC RECORD

Name and location of high school attended ______________________________

Date of graduation from high school ______________________________

If you are not a high school graduate, state in detail what equivalent education you have had ______________________________

____

College or University (in chronological order):

Name	City & State	Major	Dates From-To	Degrees Title-Date	Semester Credit-Hrs. (if no degree held)

List any technical irrigation training ______________________________

____

III. PROFESSIONAL SOCIETIES, ASSOCIATIONS OR ORGANIZATIONS

List membership in professional societies, associations, or organizations:

Organization	City & State	Type Membership	Date Joined

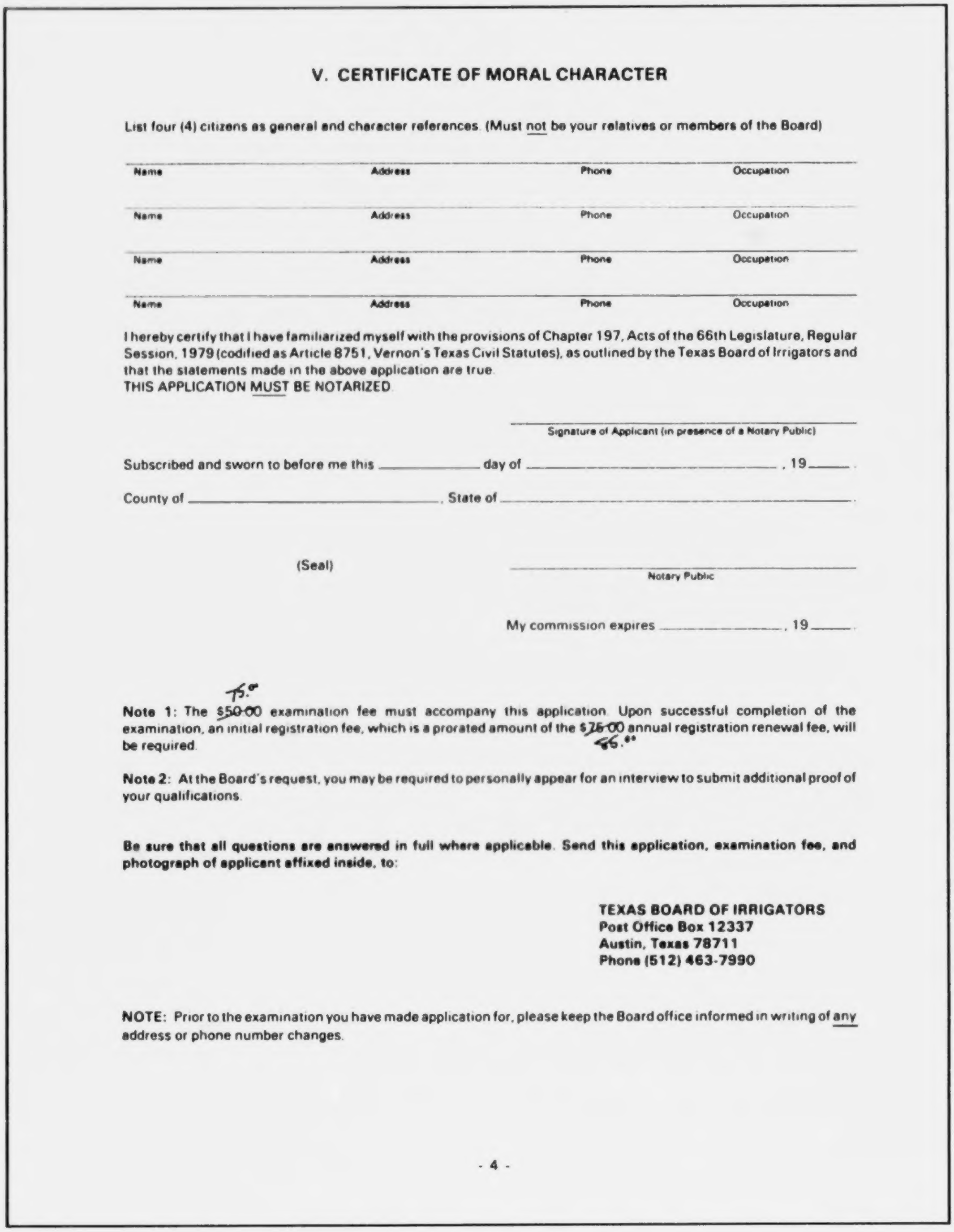
AFFIX RECENT PHOTOGRAPH OF APPLICANT
(PHOTOGRAPH MUST ACCOMPANY APPLICATION, AND SHOULD BE AFFIXED WITH TAPE OR GLUE. PHOTO DOES NOT HAVE TO BE THIS EXACT SIZE, BUT MUST BE EASILY IDENTIFIABLE AS THE PERSON MAKING APPLICATION.)

- 2 -

IV. EXPERIENCE

Start with your present position and work back in time for the last ten years Provide complete information of work done, including any in the area of Landscape Irrigation specifically (If additional space is needed, use extra sheets.)

Date	State nature, location and magnitude of work, name and title of supervisor, your duties	Work Hrs Av./Wk.	Employer Name and Address



V. CERTIFICATE OF MORAL CHARACTER

List four (4) citizens as general and character references. (Must not be your relatives or members of the Board)

Name Address Phone Occupation

Name Address Phone Occupation

Name Address Phone Occupation

Name Address Phone Occupation

I hereby certify that I have familiarized myself with the provisions of Chapter 197, Acts of the 66th Legislature, Regular Session, 1979 (codified as Article 8751, Vernon's Texas Civil Statutes), as outlined by the Texas Board of Irrigators and that the statements made in the above application are true.
THIS APPLICATION MUST BE NOTARIZED.

Signature of Applicant (in presence of a Notary Public)

Subscribed and sworn to before me this ____________ day of ______________________________, 19______.

County of ______________________________, State of ______________________________.

(Seal)

Notary Public

My commission expires ________________, 19______.

Note 1: The 75.00 ~~$50.00~~ examination fee must accompany this application. Upon successful completion of the examination, an initial registration fee, which is a prorated amount of the ~~$75.00~~ 96.00 annual registration renewal fee, will be required.

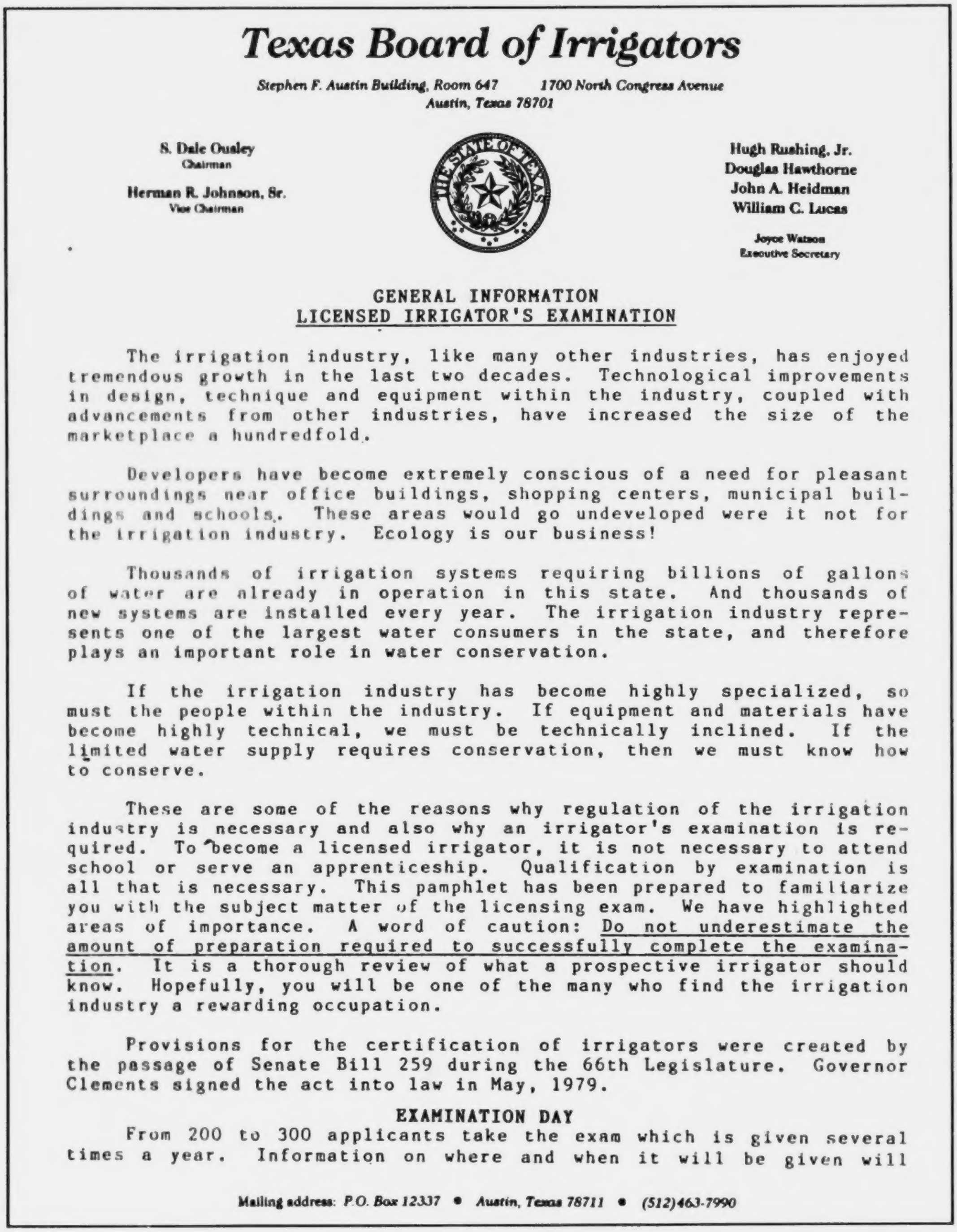
Note 2: At the Board's request, you may be required to personally appear for an interview to submit additional proof of your qualifications.

Be sure that all questions are answered in full where applicable. Send this application, examination fee, and photograph of applicant affixed inside, to:

TEXAS BOARD OF IRRIGATORS
Post Office Box 12337
Austin, Texas 78711
Phone (512) 463-7990

NOTE: Prior to the examination you have made application for, please keep the Board office informed in writing of any address or phone number changes.

- 4 -



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GENERAL INFORMATION
LICENSED IRRIGATOR'S EXAMINATION

The irrigation industry, like many other industries, has enjoyed tremendous growth in the last two decades. Technological improvements in design, technique and equipment within the industry, coupled with advancements from other industries, have increased the size of the marketplace a hundredfold.

Developers have become extremely conscious of a need for pleasant surroundings near office buildings, shopping centers, municipal buildings and schools. These areas would go undeveloped were it not for the irrigation industry. Ecology is our business!

Thousands of irrigation systems requiring billions of gallons of water are already in operation in this state. And thousands of new systems are installed every year. The irrigation industry represents one of the largest water consumers in the state, and therefore plays an important role in water conservation.

If the irrigation industry has become highly specialized, so must the people within the industry. If equipment and materials have become highly technical, we must be technically inclined. If the limited water supply requires conservation, then we must know how to conserve.

These are some of the reasons why regulation of the irrigation industry is necessary and also why an irrigator's examination is required. To become a licensed irrigator, it is not necessary to attend school or serve an apprenticeship. Qualification by examination is all that is necessary. This pamphlet has been prepared to familiarize you with the subject matter of the licensing exam. We have highlighted areas of importance. A word of caution: Do not underestimate the amount of preparation required to successfully complete the examination. It is a thorough review of what a prospective irrigator should know. Hopefully, you will be one of the many who find the irrigation industry a rewarding occupation.

Provisions for the certification of irrigators were created by the passage of Senate Bill 259 during the 66th Legislature. Governor Clements signed the act into law in May, 1979.

EXAMINATION DAY

From 200 to 300 applicants take the exam which is given several times a year. Information on where and when it will be given will be sent to each applicant. The exam is given by the Board members and other licensed persons in the irrigation industry who act as proctors. The test begins at 8:00 a.m. and ends at 5:00 p.m.

Drawing boards and T-squares, and all charts and tables will be provided, however applicants must bring their own drawing instruments and hand calculators. No other material will be allowed in the room during the test.

The exam is given in sections and you will not be permitted to leave the room except between sections. You will be allowed to ask questions of Board members only during the test.

The time required to take the exam varies. Some persons complete it in four or five hours, however the majority of applicants finish in seven or eight hours. An incomplete examination almost always results in failure.

While taking the test, applicants should conduct themselves so that they will not cast suspicion on themselves or others. Anyone caught cheating will be asked to leave without certification. You will be notified of your test results within 30 days with instructions on how to secure a license if you passed.

Comments from individuals who have taken the test have revealed that those who successfully complete the exam generally register early, read the material in the publications listed on the Recommended Study Material sheet, attend a design school or seminar and arrive in Austin the day before the exam.

Should you have any questions about the study information feel free to call our office in Austin, (512) 463-7990.

STUDY RECOMMENDATION

There are sections on the test with true/false, multiple choice, and fill-in-the-blank questions. The questions in these sections are of a general nature and deal with industry history, construction, usage, design and drafting, hydraulics, friction loss and head selection. This information can generally be found in the manuals listed on the study material sheet; however, not all the information in the exam can be found in any one manual. Therefore, we recommend that you read everything suggested by the Board. Questions concerning the Licensed Irrigators Act will also be included on the examination.

YOU MUST HAVE A MINIMUM GRADE OF 70 ON EACH SECTION.

SECTION 1 True-False - Spacing, nozzles, patterns, GPM, pressure, velocity, pipe, cement, heads, wire, valves, precipitation, percolation, design, drip irrigation, automation, rules, act, laws.

SECTION 2 Multiple Choice - Wire, valves, sprinklers, pipe, definitions, precipitation, pressure, design, rules, act, laws.

SECTION 3 Backflow Types, uses.

SECTION 4 Hydraulics Velocity of flow, pressure loss.

SECTION 5 Design Complete design of irrigation system, heads, piping, pressure loss.

SUMMARY

The Texas Board of Irrigators has attempted to give you information that will help you successfully complete the licensing examination. It is up to you to demonstrate that you have the knowledge to practice irrigation in Texas.

Certification places a responsibility on the licensee to protect the domestic water supply. The integrity of your license is affected by your actions and those of other licensed irrigators. All of us have a responsibility to enforce the provisions of this law and ensure conformance to it. We sincerely hope that, if you are certified, you will continue to expand your expertise in the irrigation field.

As you enter into your new occupation as an irrigator, we encourage you to establish a high standard of business ethics.

GOOD LUCK!

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Submit the application early

You must return the completed application, with your fee, at least one month prior to the test day.

Instructions for the exam and study materials

After you submit your application, the Texas Board of Irrigators will send you information about the exam and suggested study materials. The next two pages show examples of what you will receive.

INSTRUCTIONS FOR THE LICENSED IRRIGATOR EXAMINATION

It is the responsibility of each candidate to seek out additional information regarding landscape irrigation and its application as each candidate feels is necessary.

The basic categories of the exam encompass Design, Hydraulics, Terminology, the Licensed Irrigators Act (copy of Act is furnished with the application packet), and Material Take-Off. The written portion requires approximately four (4) hours followed with a practical design problem.

Since the privileges of this license are recognized statewide, it is necessary that you have a basic understanding of the various types of backflow devices used in this state, even though they may not be required in your locality.

It is the recommendation of this Board that you be completely familiar with the subject of design and hydraulics so you can design an irrigation system under test conditions. You may secure assistance in developing a practice design.

PLEASE BE REMINDED THAT A SCORE OF 70 OR MORE MUST BE MADE ON EACH SECTION OF THE EXAMINATION IN ORDER FOR YOU TO BECOME ELIGIBLE FOR CERTIFICATION AS A LICENSED IRRIGATOR.

You will need to bring the following instruments and equipment to the exam:

A. Engineer Scale
B. Triangle
C. Compass
D. Pencils - #2 only
E. Erasers
F. Pocket Calculator (permissable, but quiet)
G. Template (permissable if you desire to use one)

YOU WILL BE NOTIFIED APPROXIMATELY TWO TO THREE WEEKS PRIOR TO THE EXAM AS TO WHAT DAY YOU WILL SIT FOR THE EXAMINATION.

NOTE: Approved candidates MUST APPEAR for the examination at the designated date, time and place, arriving NO LESS than ten (10) minutes prior to the announced starting hour of 8:00 a.m. If you sign up for the exam you must take it on the assigned date or forfeit the examination fee. THE EXAMINATION FEE IS NOT REFUNDABLE.

For those of you who wish to travel together, an attempt by the staff will be made to schedule your group for examination on the same date. Please notify this office immediately, or include a written request with your application and fee, requesting a specific exam date to be assigned, allowing the staff to consider as many requests as possible.

Certification places a responsibility on the licensee to protect the domestic water supply. All of us have a responsibility to enforce the provisions of this law and ensure conformance to it. We sincerely hope that, if you are certified, you will continue to expand your expertise in the irrigation field.

GOOD LUCK!!

STUDY MATERIAL

Following is a suggested list of publications that may aid you in preparing for the examination.

THE ABC'S OF LAWN SPRINKLER SYSTEMS ($6.95) - plus (1.25 packaging and shipping)

Irrigation Technical Service
Post Office Box 268
Lafayette, California 94549
(415) 284-5881

IRRIGATION SYSTEMS DESIGN MANUAL ($11.00)
RESIDENTIAL DESIGN GUIDE (.50¢)
BACKFLOW PREVENTION HANDBOOK (.50¢)

Rain Bird Sales, Inc. - Turf Division
145 North Grand Avenue
Glendora, California 91740
(818) 963-9311

TURF IRRIGATION MANUAL ($23.95) - plus (1.95 shipping, plus Texas residents sales tax)

Weather-Matic Division
Telsco Industries
Post Office Box 18205
Dallas, Texas 75218
(214) 278-6131

RESIDENTIAL DESIGN MANUAL Form #490-1663 ($8.00) - plus (1.50 shipping)

Toro Company Irrigation Division
Post Office Box 489
Riverside, California 92502
(714) 688-9221 or 688-9224

CROSS CONNECTION CONTROL (Backflow Prevention Devices) No Charge

Febco
Post Office Box 8070
Fresno, California 93747
(209) 252-0791

#F50-50 CROSS CONNECTIONS, QUESTIONS, ANSWERS, AND ILLUSTRATIONS No Charge

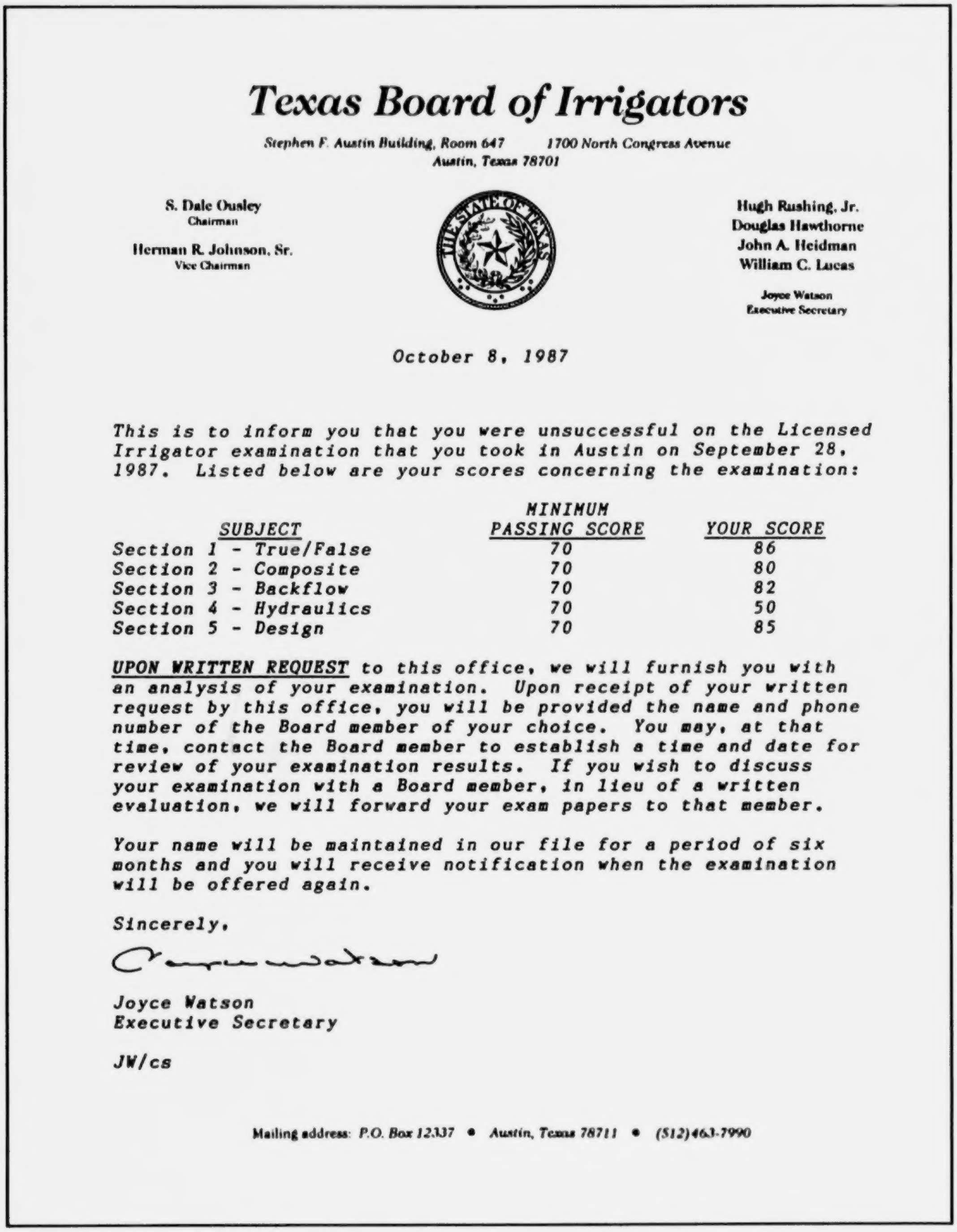
Watts Regulator Company
Post Office Box 628
Lawrence, Massachusetts 01842
(617) 688-1811

NOTE: The Board does not require you to purchase these publications. It is intended that the candidate be aware that these irrigation publications are available.

Failing the LI Exam

If you fail the LI Exam, the TBI will notify you by letter. The following page shows an example of that letter. Notice that you have the opportunity to review your examination with a Board member if you so choose.

There is no limit on the number of times you may re-take the examination. It is not necessary to submit an additional application form. However, each re-take requires prepayment of the entire examination fee and a commitment to travel to Austin.



Texas Board of Irrigators

Stephen F. Austin Building, Room 647 1700 North Congress Avenue
Austin, Texas 78701

S. Dale Ousley
Chairman

Herman R. Johnson, Sr.
Vice Chairman

Hugh Rushing, Jr.
Douglas Hawthorne
John A. Heidman
William C. Lucas

Joyce Watson
Executive Secretary

October 8, 1987

This is to inform you that you were unsuccessful on the Licensed Irrigator examination that you took in Austin on September 28, 1987. Listed below are your scores concerning the examination:

SUBJECT	*MINIMUM PASSING SCORE*	*YOUR SCORE*
Section 1 - True/False	70	86
Section 2 - Composite	70	80
Section 3 - Backflow	70	82
Section 4 - Hydraulics	70	50
Section 5 - Design	70	85

UPON WRITTEN REQUEST *to this office, we will furnish you with an analysis of your examination. Upon receipt of your written request by this office, you will be provided the name and phone number of the Board member of your choice. You may, at that time, contact the Board member to establish a time and date for review of your examination results. If you wish to discuss your examination with a Board member, in lieu of a written evaluation, we will forward your exam papers to that member.*

Your name will be maintained in our file for a period of six months and you will receive notification when the examination will be offered again.

Sincerely,

Joyce Watson

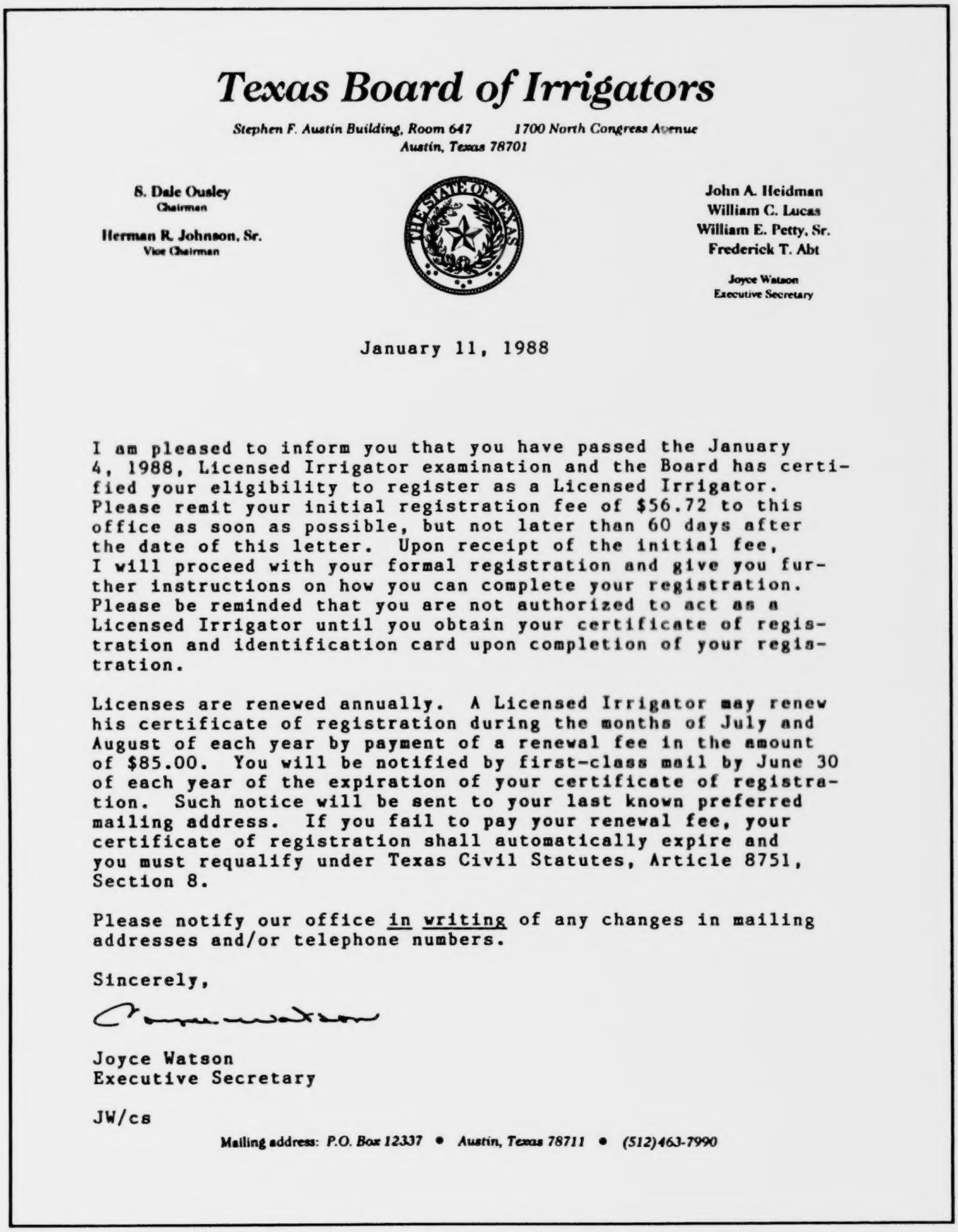
Joyce Watson
Executive Secretary

JW/cs

Mailing address: P.O. Box 12337 • Austin, Texas 78711 • (512)463-7990

Passing the LI Exam

If you pass the LI Exam, the TBI will notify you by letter. The following page shows an example of that letter. Notice that you must submit a registration fee, after which you will receive further instructions about completing your registration.



Texas Board of Irrigators

Stephen F. Austin Building, Room 647 1700 North Congress Avenue
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S. Dale Ousley
Chairman

Herman R. Johnson, Sr.
Vice Chairman

John A. Heidman
William C. Lucas
William E. Petty, Sr.
Frederick T. Abt

Joyce Watson
Executive Secretary

January 11, 1988

I am pleased to inform you that you have passed the January 4, 1988, Licensed Irrigator examination and the Board has certified your eligibility to register as a Licensed Irrigator. Please remit your initial registration fee of $56.72 to this office as soon as possible, but not later than 60 days after the date of this letter. Upon receipt of the initial fee, I will proceed with your formal registration and give you further instructions on how you can complete your registration. Please be reminded that you are not authorized to act as a Licensed Irrigator until you obtain your certificate of registration and identification card upon completion of your registration.

Licenses are renewed annually. A Licensed Irrigator may renew his certificate of registration during the months of July and August of each year by payment of a renewal fee in the amount of $85.00. You will be notified by first-class mail by June 30 of each year of the expiration of your certificate of registration. Such notice will be sent to your last known preferred mailing address. If you fail to pay your renewal fee, your certificate of registration shall automatically expire and you must requalify under Texas Civil Statutes, Article 8751, Section 8.

Please notify our office in writing of any changes in mailing addresses and/or telephone numbers.

Sincerely,

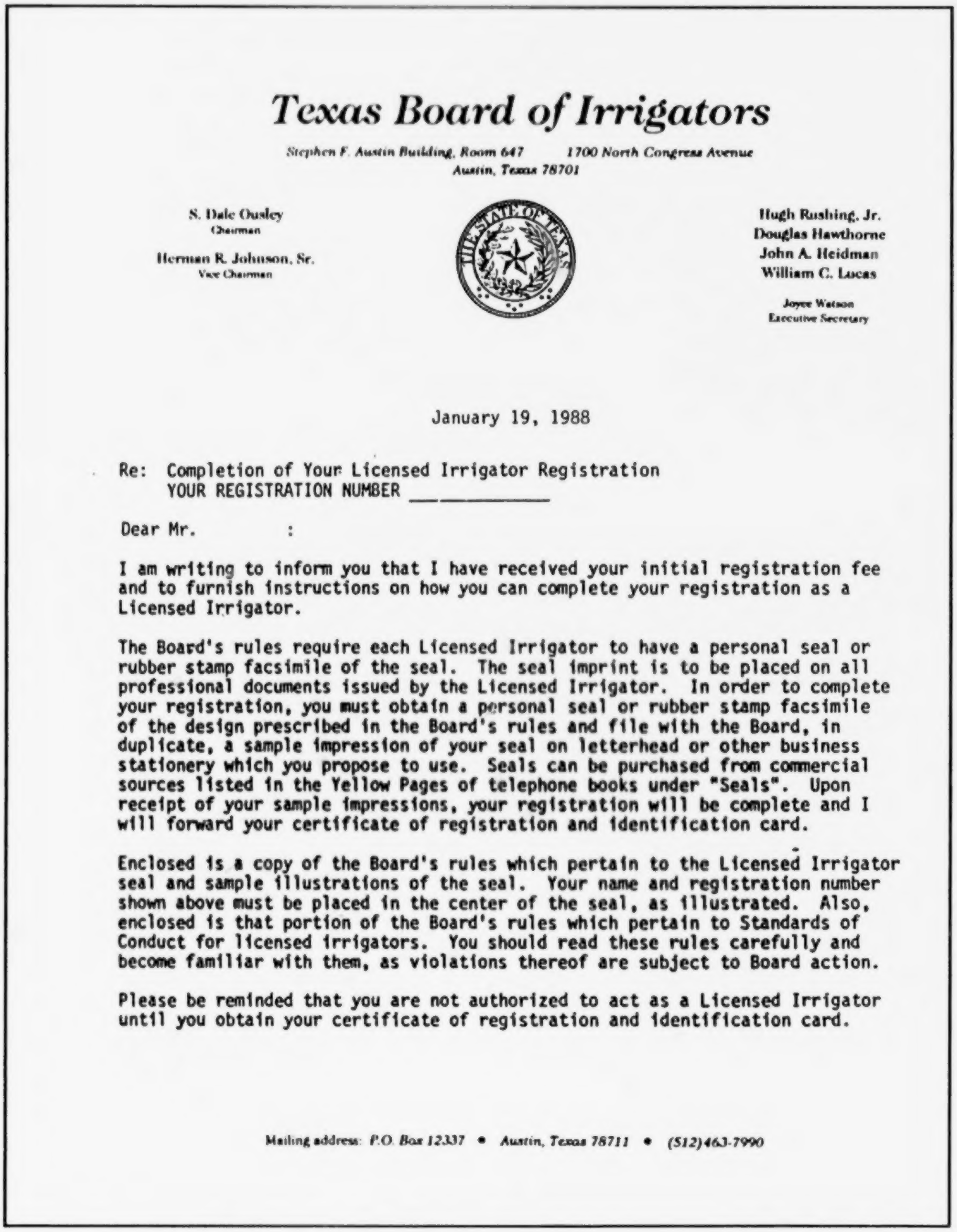
Joyce Watson
Executive Secretary

JW/cs

Mailing address: *P.O. Box 12337 • Austin, Texas 78711 • (512)463-7990*

Completing your registration

After you have passed the LI Exam and sent in your registration fee, you will receive a letter explaining how to obtain a personal seal or rubber stamp. The following two pages show an example of that letter. Follow the instructions included with the letter to obtain your personal seal or rubber stamp.



Texas Board of Irrigators

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John A. Heidman
William C. Lucas

Joyce Watson
Executive Secretary

January 19, 1988

Re: Completion of Your Licensed Irrigator Registration
YOUR REGISTRATION NUMBER ____________

Dear Mr.   :

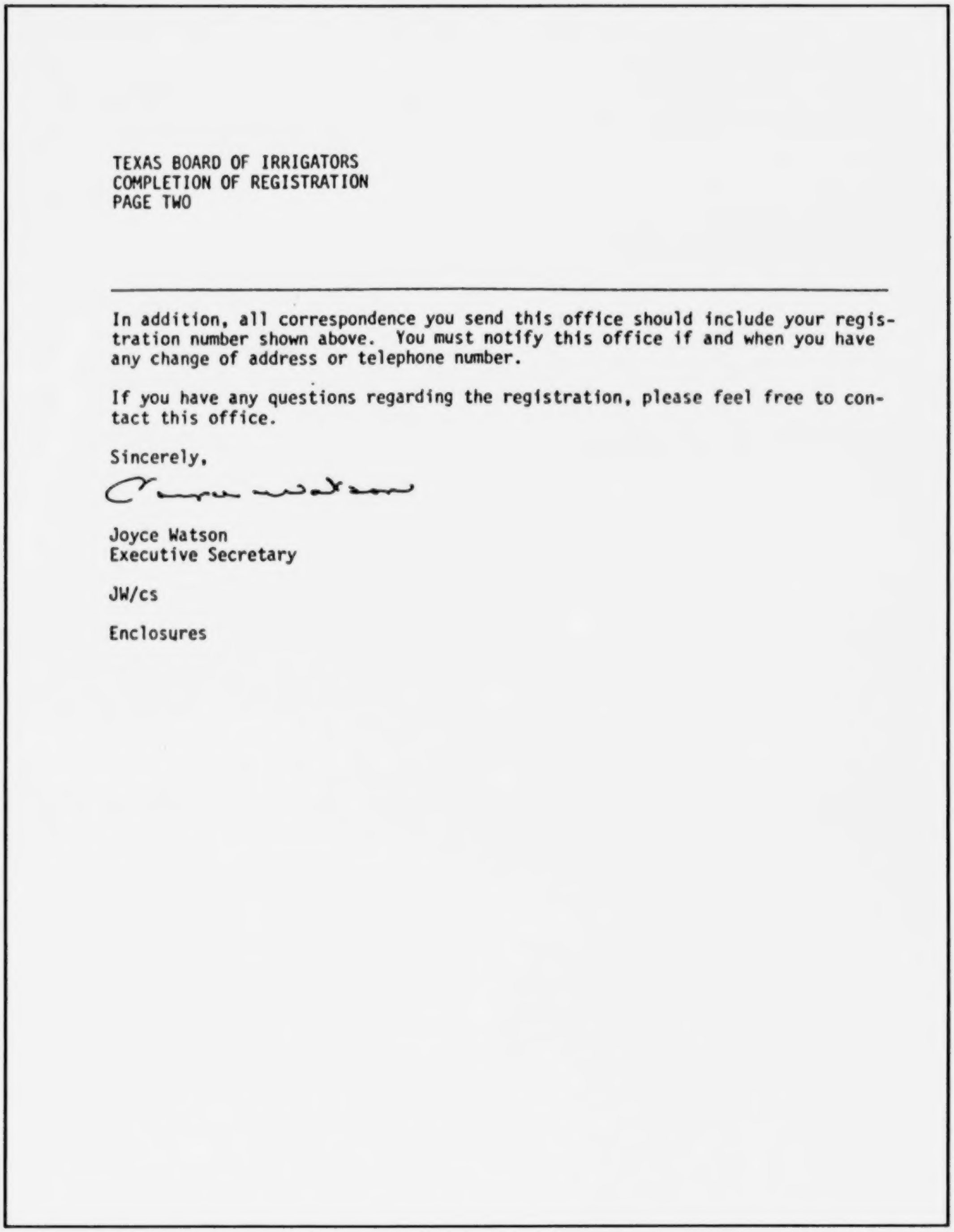
I am writing to inform you that I have received your initial registration fee and to furnish instructions on how you can complete your registration as a Licensed Irrigator.

The Board's rules require each Licensed Irrigator to have a personal seal or rubber stamp facsimile of the seal. The seal imprint is to be placed on all professional documents issued by the Licensed Irrigator. In order to complete your registration, you must obtain a personal seal or rubber stamp facsimile of the design prescribed in the Board's rules and file with the Board, in duplicate, a sample impression of your seal on letterhead or other business stationery which you propose to use. Seals can be purchased from commercial sources listed in the Yellow Pages of telephone books under "Seals". Upon receipt of your sample impressions, your registration will be complete and I will forward your certificate of registration and identification card.

Enclosed is a copy of the Board's rules which pertain to the Licensed Irrigator seal and sample illustrations of the seal. Your name and registration number shown above must be placed in the center of the seal, as illustrated. Also, enclosed is that portion of the Board's rules which pertain to Standards of Conduct for licensed irrigators. You should read these rules carefully and become familiar with them, as violations thereof are subject to Board action.

Please be reminded that you are not authorized to act as a Licensed Irrigator until you obtain your certificate of registration and identification card.

Mailing address: *P.O. Box 12337 • Austin, Texas 78711 • (512)463-7990*



TEXAS BOARD OF IRRIGATORS
COMPLETION OF REGISTRATION
PAGE TWO

In addition, all correspondence you send this office should include your registration number shown above. You must notify this office if and when you have any change of address or telephone number.

If you have any questions regarding the registration, please feel free to contact this office.

Sincerely,

Joyce Watson
Executive Secretary

JW/cs

Enclosures

Studying for the exam

One of the best ways to prepare for the exam is exactly what you are doing--taking a study course through a community college.

You may wish to supplement your learning. If so, you have at least of couple of options:

> Take a study course offered by various suppliers of irrigation products. Use your own discretion in choosing one of these. Some of them are abbreviated in content and may tend to show case only the products offered by the vendor.
>
> Obtain and read all of the study materials suggested by the TBI.

Regardless of how you choose to study for the exam, do so over a reasonable time period. Do not try to cram for the exam at the last minute.

Accommodations in Austin

Arrive in Austin the day before your scheduled test day. Otherwise, you run the risk of delay unless you live within easy driving time. Do what is necessary to be fresh and un-hassled.

The LI Exam has been given in several different locations over the years. Presently it is conducted at the Howard Johnson Plaza-Hotel South, 3401 I-35 South, Austin, Texas, (512) 448-2444. Take the I-35 S. and Woodward St. exit.

The hotel has airport shuttle service, a restaurant, lounge, ample parking and quiet, comfortable rooms. It also provides the "call for scores" as a courtesy service to persons taking the examination.

Pluses and Minuses

It is convenient, but may be somewhat more costly, to stay at the Plaza-Hotel South where the examination is offered. There are some disadvantages, however, of which you should be aware. The dining room opens at 6:30 AM and your line up time is at 7:00 AM. Because of the number of persons present for breakfast, the food service may take longer than the amount of time you have to spare. The luncheon is similarly crowded and may also require lengthy waiting on the food service.

One solution is to eat the buffet, which does not require kitchen preparation time that cuts into your limited examination time.

Although there are a number of dining establishments in various locations in Austin, none are within easy walking distance of the Howard Johnson, Plaza-Hotel South. Between Woodward exit and Oltorf--one mile to the north--are a Dennys and a Kettle restaurants and a Lubys cafeteria.

All of them are a one-to-two mile round trip. They are options if you have transportation and wish to arise early, go out, and eat away from the crowd.

Check-in Procedure

At approximately 7:00 AM on the day you are scheduled to take the examination, an identification and check-in procedure will begin at a table near the main testing room. Usually, a TBI staff member, a Board member, and possibly others will begin the check-in process for that day's testing.

You must have your permit to take the test (a colored cardboard ticket which was sent to you upon submission of the exam fee a minimum of 30 days prior to the exam day) and your Texas Drivers License or other ID that has a photograph affixed.

The permit and the photograph ID will be checked against your personal file folder, which contains the completed application and any correspondence from you.

If all matches, your card and ID will be returned and you will sign-in on a numbered line in a sign-in log. Record the number on your permit in the space provided. You will use that number--NOT YOUR NAME--on every answer sheet, drawing, or calculation sheet you turn in for grading the rest of the day! You will then proceed to the main examination room.

All persons are usually logged-in by shortly after 8:00 AM and are ready for the examination. A member of the Board will welcome the group, introduce the other Board members and TBI staff present, and give some details of test procedure.

Layout of the examination room

The hotel ballroom will be set up with conference tables and chairs, arranged in rows facing one wall. Tables will usually be arranged in groups of two to four, end-to-end depending on whether they are along the wall or in the center of the room. All tables will have table cloths and four testing locations per block of two tables. Center sections may have eight or more testing stations set up on a long run of tables. Adequate aisles between rows and columns of tables are provided because participants will be moving about the room to log-in and log-out for various sections of the test, sharpen pencils, request assistance, etc.

For those of you who smoke or who wish to avoid smoke from others, the back few rows are usually reserved for smokers during the examination. No cigars or tobacco chewing in any form is permitted.

A typical table arrangement with four seats includes a "drawing pad" station, a written exam station, another "drawing pad" station, and another written exam station.

You may not have briefcases, etc., at your table during the examination. They will have to be placed in the back of the room.

Recognizing the materials

Rather than drafting boards and T-squares being provided as in the past, large cardboard "pads" (about 18" x 22" in size) with a length of masking tape are provided. Your drawing for the design portion of the test will be placed on this cardboard pad. This eliminates the need for a T-square. This also allows those who take the written portion first to immediately proceed to the drawing portion since extra "pads" are available at the front of the room.

All written examinations are bound in a three ring notebook. Do not write in the notebook. Record your answers on the Scantron answer sheets, which will be read and graded electronically.

A set of official TBI Charts and Tables is provided in the back of the test notebook. They are the only charts and tables you may use on the test.

As you log in and are ready to walk into the test room, you are handed the TBI Test Booklet. Take the notebook along with your own drawing and calculating equipment and locate a testing area you can be comfortable with. If you wish to start the examination with the drawing, select a chair in front of a "drawing pad." If you wish to start with the written portion, select a chair in front of a space without a "drawing pad." You may not open the notebook until told to do so. As soon as you are able, though, turn to the Official Charts and Tables in the back section of the notebook and familiarize yourself with them. The arrangement of the tabular material and charts may be different from anything you are used to using. Therefore, a few minutes at the beginning of the entire test may save you much frustration later when time is of the essence.

One to two hundred persons may be taking the exam on any given day. Concentrate on your own work. Give yourself every advantage for success.

Materials you may use

The TBI supplies the examination notebook with the official tables and charts, cardboard "drawing pads," machine graded Scantron answer sheets (100 response and 50 response depending on the section), #2 soft lead pencils, and scratch paper.

The personal materials permitted are drafting instruments (triangles, engineers scale, erasers, templates), and a calculator. No "singing or musical" calculators please, unless you can turn them off to avoid distracting other participants.

The templates may be shape or symbol aids. Specific shapes and symbols are required for a good score on the design. Also allowed are commercial or self-prepared spacing templates for triangulated head layout. Caution: the head sizes specified in the Official Charts are the only ones you may use on the exam. (Do not bring too many personal materials that you cannot use.)

All answer sheets and design problems are provided for you. You may find it useful to get scratch paper from the front of the room.

Also, you may want to bring several sheets of tracing paper or onion skin for trial placement of heads and adjustment of zones prior to drawing in the final design. It is far easier, quicker, and neater to make mistakes on expendable tracing paper than to erase completely and re-draw several times on the design test itself. Keep your drawings clean and neat. Another helpful item is stick-on notes on which you can jot reminders and write down starting times and quick calculations.

Examination sections

The exam comprises five section tests, which you must complete within the eight hour day (8:00 AM to 5:00 PM). The sections are untimed. You may spend as much time as you wish on a section; however, you must complete all five within the eight hours. You do not have to go to lunch if you do not want to.

After you complete each section, you return that answer sheet to the check-in/out station outside the conference room. You will initial a designated area on a control sheet showing you completed and handed in that score sheet. You may now take any length of break you wish or you may immediately check out the answer sheet for the next section.

You may begin with either the Design Drawing or with Section 1 of the written portion. Some participants prefer to do the drawing first because of the time involved (usually 3 to 5 hours). If you wish to do the design first, be in line early. Log-in, get your assigned number and Exam Notebook, then quickly select a drawing station in the testing room. At the proper time, you will be handed your design drawing and a Scantron answer sheet for Section 5. If you choose the written portion first (by selecting a "non-drawing station"), you will be handed a Scantron answer sheet for Section 1.

The sections of the LI Exam contain three types of questions: true/false, multiple choice, and fill-in-the-blank, all answered on the Scantron electronically graded score sheet. The questions are of a general nature and deal with industry history, construction, usage, design and drafting, hydraulics, friction loss, head selection, and the Licensed Irrigators Act. This information can generally be found in the manuals listed on the study material sheet. Not all the information on the exam, however, can be found in any one manual. Therefore, if at all possible, read everything suggested by the Board.

The following summary lists the topics covered by the various sections:

Section 1: Spacing, nozzles, patterns, GPM, pressure, velocity, pipe, cement, heads, wire, valves, precipitation, percolation, design, drip irrigation, automation, rules, act, laws.

Section 2: Wire, valves, sprinklers, pipe, definitions, precipitation, pressure, design, rules, act, laws.

Section 3: Backflow prevention devices, uses.

Section 4: Hydraulics, velocity of flow, pressure loss.

Section 5: Design, complete design of irrigation system, heads, piping, pressure loss.

Pacing and efficient time management

No matter which part of the exam you start on, you must keep track of the time remaining for other phases of the examination. A rough rule of thumb is that the drafting design takes about half or more of the eight hours. The first three sections usually take about 2 to 3 hours. Respectively, they involve 100 true/false questions, 50 multiple choice questions, and 50 true/false questions.

The hydraulics section, which involves calculations and reference to charts and tables, takes about an hour. Care should be taken that you do not get mixed up when recording your answers. You may be consulting particular places on as many as four pieces of paper and calculations on a calculator in getting any one answer.

The written portions take from 3 to 4 hours out of a total of 8 (9 hours if you do not eat lunch). You then have 4 to 5 hours remaining to do the design section.

If you do the design section first and finish everything in 3 to 4 hours, then you can do the written sections (in order, no skipping around) in the time remaining.

Grading

The written sections and drawings are graded as soon as they are returned to avoid a log jam at the end of the day. Naturally, the written sections, which require less time to complete than the drawing, will begin to be turned in within the first hour or so. Therefore, people will be moving around as they leave the room to check in a finished section, check out a new answer sheet or take a break between sections. There is an orderly process of sign-in and sign-out for the various sections. Be prepared to wait in line when you go to the examination table (same table as used for the log-in).

Once you return your answer sheet you may not get it back. You must move on to the next section.

Posting of scores

An announcement will be made as to the anticipated time the notification of pass/fail will be posted on the door of the grading room. A sequential list of numbers will be posted with a pass/fail. The numbers include the number that you placed on all answer sheets and designs. The score reflects the overall score for the entire examination. The grades on individual sections will not be posted.

Remember, you must make 70 points or more on each of the five sections, or you must retake the entire examination.

Unofficial reporting

The desk clerk at the hotel will have a copy of the same pass/fail list that is posted on the door. If you have to leave Austin before the scores are posted, you may call the desk clerk to get an unofficial notification of your score. Remember, this is a courtesy of the hotel, not an official action of the TBI staff.

Official notification of your score will come by mail, usually within two weeks, to the address on your application. Do NOT call the Board office for grades. In some instances, several examination days may be required to accommodate all applicants and the staff will be involved in conducting examinations over several days.

(This page included for duplexing.)

3. Irrigation - Then and Now

Overview

This section introduces the subject of irrigation and relates how it has evolved as an integral part of human existence. Specific to Texas is a discussion of the Texas Board of Irrigators Act. This section also discusses irrigation as a profession, the improvements in irrigation products, and the vocabulary common to the irrigation business.

Irrigation defined

We humans have actively changed our surroundings since the very beginning. And, since most of this planet is water, it stands to reason that we have spent much time moving water from one location to another. In fact, the definition of irrigation is "to supply with water."

Irrigation dates back as far as we have recorded history. People from all ages and in all parts of the world have always manipulated water to keep themselves, livestock, and vegetation alive.

Diversion as an early form of irrigation

One of the earliest forms of irrigation was diversion. Humans would sometimes want to change the direction of a natural source of running water, such as a river or stream. They may have wanted to bring water closer to their habitat, or to get the water away from something that they wanted to protect. In either case, they needed to divert the water.

Today, we are surrounded by many types of water diversion. Canals, levies, and dams are obvious ones. But even the curb on a street serves to divert water. Diverting water is so commonplace that we seldom stop to consider the places where irrigation got started.

Early examples of irrigation

One very early example of irrigation comes from the area that we now call the Middle East, in a region low along the borders between Iraq and Iran. That area was once referred to largely as Persia. It is there that the Tigris and Euphrates Rivers merge to form the Shatt al-Arab, a place that some believe to be the location of the Garden of Eden.

Because the Shatt al-Arab runs through low marshlands, inhabitants in that area had to change the level, the vertical height, of the water to reach their crops. They needed to irrigate date groves.

Euphrates Wheel

Over time, the inhabitants created something called the Euphrates Wheel. It was a mechanical device powered by an ox, donkey, or even a person. The muscle power would turn a wheel which had a series of buckets on it. The buckets would fill with water and, as the wheel rotated and the buckets were turned upside down, would empty into a canal. The canal was slightly higher that the level of the river and would carry the water to the date groves.

The Euphrates Wheel operates basically like a booster pump to lift water from one level to another. It offers a cheap, fairly efficiently way to provide irrigation water and is still used today.

Roman aqueducts

Several thousand miles northwest of the Shatt al-Arab lived another ancient people who devoted much effort to diverting water. The Romans built a lavish network of aqueducts, sections of which still remain.

Some of the aqueducts had rock walls that contained fluid chambers. The chambers had a measurable drop so that water would flow through them gradually under its own hydrostatic pressure. The ancient Roman architects were ingenious enough to build some of the walls without mortar, yet the chambers have survived for thousands of years.

Windmills

In an area of Europe still further northwest, the inhabitants wanted to divert water for a different reason. The Netherlands had long been plagued with tidal influxes that would flood much of their land. Their need was to remove water to make arable fields.

The Netherlanders created wind driven pumps in the form of windmills. They used the windmills to drain the land, and built earthen dikes to keep the water from flowing in again. The combination of windmills and dikes worked successfully and much of the Netherlands is now arable. You have probably seen photographs of the beautiful tulip fields in the Netherlands. Tidal waters once flooded most of those fields.

Irrigation in Texas

Let us move into more recent times. In Texas, for example, the practice of irrigation is fairly recent, at least historically speaking. Around 1890 and early 1900, it became important for us to use some of our water resources on vegetation. Prior to that, any farming was done in locations with ample rainfall or in alluvial soils near waterways.

An old friend revisited

But we began to populate the state and push out into areas where water was not so easily had for raising vegetation or for drinking. Once again, humans had the need to divert water. We adapted an idea that was already being used in Europe, in places like the Netherlands--using the wind to divert water.

Danie[illegible]day introduced the wind pump to the United States in 1854. And even though the device pumped water, it came to be known as the windmill. In 1883, Stewart Perry started building windmills out of steel. They were not very efficient, but they were durable, reliable, and inexpensive to operate. The windmill helped wet the West.

But even as the popularity of the windmill reached its peak across Texas, another device in New York City was capturing the imagination of the country. The first public power station went into operation in September of 1882, producing direct current electricity. Within a few years, scientists were demonstrating the usefulness of alternating current. Trouble was, they needed some way to generate it on a large scale. They needed something like . . . like water falling from a reservoir.

Power to make power

And so it was that once again humans diverted water for their needs. People quickly realized that reservoirs could provide more than just a means to generate electricity. They could also provide irrigation water. The race to build reservoirs was on, and Texas was among the racers.

Buchanan Dam

Texas, like most states, has an extensive system of dams that was begun years ago. For instance, early in the 1930's, during the Great Depression, Buchanan Dam was built on the Colorado River. The Colorado would fluctuate from flood to drought, either ruining crop land or failing to supply sufficient water.

Since 1930, there have been over eight major dammings on the Colorado River alone (and the creation of eight major lakes). Not all of the dams in the state are for irrigation. But many, particularly the smaller dams, do provide water for irrigation.

From crops to lawns

For many years, irrigation in Texas was used strictly for agriculture. We developed various ways during those years to irrigate crops, such as center pivot irrigation, furrow irrigation, and surge irrigation.

During the years 1935 to 1950, Texans did very little watering of plants for beautification. Residential irrigation was a practice for only the very wealthy. Think how times have changed!

We have developed here in Texas a love for the growing of plants. We spend millions of dollars to develop programs for irrigating crops. Many of the crops are cash crops, not food crops. In addition, we spend tremendous sums on irrigation just for beautification, which has nothing to do with the food chain at all.

Currently, 10% to 15% of all the buildings built in Texas provide for the watering of turf grasses and bedding plants for beautification. The percentages refer to residential and light commercial irrigation.

This involves a tremendous amount of money. The total do-it-yourself sprinkler business in Texas-- everything from hose bibs to garden hoses to complete sprinkler systems -- is in the millions of dollars in annual sales.

Irrigation has become a big industry that impacts many people. And, as is usually the case under such situations, a regulatory body arises to address the situation. And so it was for Texas.

TBI Act and other laws

The Texas legislature passed the Texas Board of Irrigators (TBI) Act in 1979 and created the Texas Board of Irrigators. The express purpose of the Board is to bring some accountability to the installers of sprinkler systems. The TBI Act addresses only residential and light commercial sprinkler systems, not agricultural irrigation.

The legislators saw a rapidly evolving industry that needed regulatory control. The consuming public needed some assurance that the installers of sprinkler systems had certain knowledge before tampering with potable water supplies.

The TBI Act is included as Appendix A of this book. Appendix B contains the TBI permanent rules.

Sunset Law

In Texas, legislative acts that create commissions, committees, or any other bureaucratic entity have to be reviewed from time to time to determine the validity of the act. The law that requires this is the Sunset Law. The TBI Act, for example, is scheduled for its review in 1991.

The Texas Board of Irrigators is a funded operation and charges a fee for licensure as well as an annual renewal fee. Over 4,000 persons have taken the licensure examination.

How the TBI Act affects you

The TBI Act directly affects you. The Act requires that anyone who "sells, designs, consults, installs, maintains, alters, repairs, or services" an irrigation system must be a Licensed Irrigator, or must work under the direct supervision of a person who meets those qualifications.

The Texas Board of Irrigators, however, does not have infinite control over the irrigation business. A number of installers practice illegally in our state. You may wonder, "What does it matter whether or not I'm licensed?" To answer that, let us first talk about laws in general.

The reason we have laws is to protect the community at large. For example, we have laws governing fair trade practices so that you are legally obligated to tell the truth if you are trying to sell something. In addition, we have truth in lending acts so that if you borrow money and pay interest on it, the lender must tell you what the total financial burden of the loan will be.

So it is with the TBI Act: we must protect the potable water supply, the drinking water, for the community at large. The simple fact is that we cannot live without water.

Ethics and irrigation

Complying with the law is one reason for becoming a Licensed Irrigator. But there are other reasons, ethical reasons, that perhaps are equally as important. As a professional irrigator, you are responsible for protecting our potable water supply and for treating the consumer fairly.

In order for us to have any longevity of our industry and to increase the popularity of irrigation, we must do business with this sort of responsibility in mind. It seems that few groups in the business world have a worse reputation than installers of sprinkler systems. One example may be the used car salesperson in a bright plaid jacket. And in some cases, even that person appears more trustworthy than an irrigator.

As irrigators, we must realize that much of the public views us as irresponsible liars, without professionalism, and ignorant of the technologies involved in our own business. We often appear to be just as likely to sell them a system that will not work and will violate a law, as we are to sell them a system that will be effective, efficient, and serve their needs. And all too often, the public is right!

Improving public opinion

How can you help improve the public's opinion of irrigators? First of all, consider yourself a professional irrigator, not just "some person who installs sprinkler systems." Consider yourself belonging to a profession that demonstrates responsible, ethical practices.

As a united group, we must comply with local ordinances and regulations as well as with the TBI Act. Further, we must support efforts to conserve water, efforts aimed at preventing the predicted four-fold increase in the cost of water by the year

2000. Our compliance and conservation efforts will help show that we are a profession to be trusted rather than doubted.

Watering - Then and Now

Residential Irrigation systems have become more and more commonplace over the years. But it was not always so. For example, if you wanted to water your lawn during the 1930's, you probably had a fairly archaic variety of hose and some sort of sprinkler attached to the end of it. During the 1940's--if you were wealthy--you may have had an underground sprinkler system made of galvanized pipe and copper tubing. Such systems were not highly efficient and required somebody to manually open and close valves.

By the 1950's, the push was on in California, Florida, and even parts of Texas, for the luxury of an automatic sprinkler system. Automatic timers were available, as well as materials that made such systems fairly efficient. Not just the wealthy wanted sprinkler systems, but the middle class began to see them as valuable additions to a property.

The 1960's brought many changes to our country, including an increase in residential irrigation and beautification. Sprinkler systems became increasingly common, particularly along the West Coast. Sprinkler systems continued their popularity throughout the 1970's as well.

By now, the late 1980's, many homeowners are familiar with sprinkler systems as a necessary part of a residential property. The concept of how to water a lawn has evolved from hoses and hose-end products, to underground, automatic sprinkler systems.

Underground sprinkler systems

Underground sprinklers began with fixed orifice nozzles buried in the ground. The nozzles were usually heavy brass and very expensive. Today, underground sprinklers have evolved from being made of brass, bronze, and copper, to thermoplastics such as PVC, ABS, and polyethylene (PE). These synthetic materials are less expensive than metal, easier to work with, less corrosive, and more durable.

Sprinkler systems have progressed from having spray heads with a fixed nozzle orifice to spray heads with an adjustable nozzle orifice to various types of sprinklers that throw a long stream. Some heads are gear driven; others even make a square pattern. The principles of mechanical engineering are very much a part of modern irrigation products.

Sprinkler products and methods improve

The evolution of the products themselves is also interesting. Hose-end products began as fixed nozzle, or fixed orifice, attachments that scattered water from the end of a hose. You had to manually open a valve at the house to get water to the hose-end attachment, and you had to move the attachment to distribute water over a large area.

People got tired moving the attachments, which opened the door to another product: the walking sprinkler. This mechanism is a moving sprinkler, usually shaped like a tractor, that drags the hose with it. Arms on top of the tractor rotate and distribute water. Water-powered gears propel the sprinkler.

Other products that evolved were mechanical valves designed to operate with moving sprinklers and shut off the water to the sprinkler. Spring powered timers used to control watering intervals also appeared on the market.

Demand for better products

The products have evolved because of a demand for better products. The consumer of the '80's, for example, spends a great deal of money and research on anything concerning home improvement.

For example, central air conditioning, insulation, and carpeting were luxury items in the '50's. Such items began to be a fashion in the '60's, and a requirement in the '70's. They have become commonplace in the '80's. The point of all this is that most consumers with whom you will deal understand much about the technologies available today.

Learning aids:

Glossary

Consumers have read enough, and seen enough, to be knowledgeable about many subjects. Not just products evolve, so does the knowledge level of the public. One of your challenges as a professional irrigator is to be knowledgeable about irrigation products and practices. A good place to begin your understanding is with the glossary at the back of this book.

Subject review

After you explore the glossary, complete the subject review for this section.

Subject Review

Irrigation - Then and Now

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Many methods of irrigation have been employed in Texas since 1860.	
2. The process of product evolution has had little effect on consumers of sprinkler materials.	
3. Less than 25% of the homes and buildings in Texas have sprinklers.	
4. In areas where no local regulations are in force, the irrigator may use his or her favorite method to prevent backflow.	
5. Water costs are predicted to decrease by the year 2000 because of continued efforts in education and conservation.	
6. "T.B.I." stands for Texas Board of Irrigators.	

Statement	Answer
7. An anti-siphon device is also called a vacuum breaker.	
8. Diversion was one of the earliest forms of irrigation, but is no longer used today.	

4. Controlling Water Flow

Section overview

This section discusses the common ways in which the flow of water is controlled to and through sprinkler systems. The first area of discussion involves water meters, cross connection, and the importance of backflow prevention. Also presented in this section is an explanation of valves and controllers.

Water Meters and Cross Connection

Water meter defined

A water meter is a device that registers the amount of water, typically in gallons, used by a residence or business. Municipalities install and own the meters. A property can have more than one meter if the property owner so desires. This allows a sprinkler system to be on its own meter, for instance.

Water meters are measured in inches. This is the size of the orifice through which the water passes. The most common meter sizes are 5/8, 3/4, 1, 1-1/2, 2, and 3. Although water meters come in different sizes, you will often find the same size within a neighborhood or locale. For instance, the meters in one neighborhood may all be 5/8 inch. In another neighborhood they may all be 3/4 inch.

Pressure loss and flow rate

You will need to know the size of the water meter to install a sprinkler system because of two reasons: pressure loss and flow rate.

The meter reduces the pressure of the water. This reduction, caused by friction, is called pressure loss or pressure drop. The subject of pressure loss is explained later in the course. For now, just remember that the smaller the size of the meter, the greater the amount of pressure loss.

The pressure loss, in turn, affects the flow rate of the water. The flow rate is measured in gallons per minute. Water meters are rated as to their flow capacity. That is, the rating tells how many gallons of water can pass through the meter in 1 minute at a given water pressure. For example, with a water pressure of 60 pounds per square inch (psi), a 1 inch water meter is rated at 30 gallons per minute. At the same water pressure, a 3/4 inch meter is rated at 22 gallons per minute.

Static pressure and working pressure

When discussing water pressure, irrigators distinguish between static pressure and working pressure. The pressure of water when it is not moving is called static pressure. The pressure of water when it is moving is called working pressure. Static pressure and working pressure are also discussed later in the course.

If the working pressure is too low for a sprinkler system to operate correctly, the only solution may be a larger water meter. The property owner would have to contact the city water department to have a larger meter installed.

Locations of meters

Water meters are not located in any one specific place. They may be on the front side of a property, on the backside, or even in a basement. Usually, they are located fairly close to the main water line. The ones that are buried are protected by some sort of box that commonly has a lid.

A sprinkler system is connected to the water supply at some point between the meter and the house or business. This point is often at the water meter because the supply line is most easily found there. The water supplied to houses and businesses is potable, meaning that it is suitable to drink. When you install a sprinkler system, you connect it to the potable water supply. Any connection made to a potable water supply is called a cross connection.

Cross connection defined

In Texas, cross connection is closely regulated by city ordinances and even by state law. To legally make a cross connection in Texas, you must be a licensed professional engineer, a licensed plumber, a licensed irrigator, or a licensed installer of irrigation systems. A homeowner also may legally make a cross connection on his or her own property. However, the homeowner must obtain a permit to make the cross connection.

Why all the fuss over cross connection? Without proper safeguards, a cross connection could allow hazardous materials to enter the supply of drinking water. A condition such as that, fluids flowing backward, is called backflow.

Backflow

In the appendix of this book is a publication from the Febco Company titled Cross Connection Handbook, and one from the Watts Regulator Company titled 50 Cross Connection Questions, Answers, and Illustrations. Please turn to the appendix and entirely read both of those publications. They will greatly help your understanding of cross connection and backflow.

After you finish reading the publications, return to this section and continue with the subject review on water meters, cross connection, and backflow prevention.

Subject Review

Water Meters, Cross Connection, and Backflow Prevention

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Any connection made to a potable water supply is called a ______ ______.	
2. Backpressure occurs if the ______ pressure in a line exceeds the pressure in the supply line.	
3. A device that can be attached to a hose bibb to prevent backflow is called a hose bibb ______ ______.	
4. An atmospheric type vacuum breaker ______ be used under continuous pressure.	
5. ______ space can be used to separate a potable water supply from a nonpotable water supply.	
6. A pressure type vacuum breaker must be installed ______ the usage point.	

Statement	Answer
7. Impaired water that is not an actual hazard to the public health is said to be ______.	
8. Water that is an actual hazard to the public health is said to be ______.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The main supply line from a residential water meter to the house is usually a 1" diameter pipe.	
2. The two forms of backflow are backsiphonage and backpressure.	
3. The most common form of cross connection is the ordinary water hose.	
4. An anti-siphon vacuum breaker protects against backpressure backflow.	
5. In residential areas that have alleys, the water meters are always located beside the alleys.	
6. Depending on local codes, an atmospheric type vacuum breaker can be used on lawn sprinkler systems.	
7. A strainer or filter will help protect a backflow preventer from clogging.	
8. The "size" of a water meter refers to the volume of water that can pass through it.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. A common example of backsiphonage is A. Draining water from an ice chest through the drain cock B. Forcing pressurized water through a sprinkler head C. Drinking a liquid through a straw D. The way in which a drip coffee maker discharges water E. The way in which a gasoline pump dis charges gasoline F. None of the above	
2. One way to help protect a backflow preventer from leaking is A. To reduce the water pressure to the system B. To reduce the number of heads in the system C. To install the backflow preventer higher than the supply line D. To install a strainer or filter on the upstream side of the preventer E. Both A and B F. Both C and D	

Statement	Answer
3. Leakage from a backflow preventer is normally caused by A. Too much water pressure B. Too many heads for the backflow preventer C. The "O'Hearn effect" of siphonage combined with reverse osmosis D. Foreign matter lodged on the seating area of the valve(s). E. Both A and B F. Both C and D	
4. The ways to protect potable water from a cross connection include A. Fluid gaps, osmosis flow preventers, uniflow valves B. Air gaps, double chamber guards, siphon modulators C. Double check valves, reduced pressure backflow preventers D. Air gaps, atmospheric vacuum breakers, pressure type vacuum breakers E. Both A and B F. Both C and D	
5. A pressure vacuum breaker must be installed A. 4 inches above the highest outlet B. 6 inches above the highest outlet C. 8 inches above the highest outlet D. 10 inches above the highest outlet E. 12 inches above the highest outlet F. None of the above	

Statement	Answer
6. Some states require that A. All types of backflow prevention devices be tested once a year B. Only atmospheric vacuum breakers be tested once a year C. Only pressure vacuum breakers be tested once a year D. Only reduced pressure principle devices be tested once a year E. Both B and C F. None of the above	
7. Continuous pressure means that pressure is being supplied to a backflow prevention device A. All of the time B. For more than 50 minutes each hour C. For periods over 18 hours at a time D. For periods over 15 hours at a time E. For periods over 12 hours at a time F. None of the above	
8. If you install an atmospheric type vacuum breaker, it must go on the ______ side of the last control valve. A. Supply B. Discharge C. Left D. Right E. Water meter F. None of the above	

Valves

Valve defined

In irrigation, a valve is a device that controls the flow of water. Valves are manufactured today in a variety of plastics and metals. Valves, just like pipe, need to be correctly sized because a certain amount of pressure loss occurs at each valve. You will learn more about this in Section 6, Layout and Design.

Aside from their material, valves may be discussed several ways: by how they operate, such as manual or automatic; by their configuration, such as ball or gate; or by their purpose, such as drain or anti-siphon.

A "manual" valve is one that requires a human to manually open or close the valve. An "automatic" valve is one that can open or close without human interaction. Automatic valves operate by either electricity or hydraulics, or a combination of the two.

Valve operation

Actually, some valves also use gravity to help them operate, such as the gravity ball-type drain valve or the gravity-type check valve. But to keep from over complicating the discussion, we will classify automatic operation as either electric or hydraulic. Figure 4-1 classifies valves by how they operation.

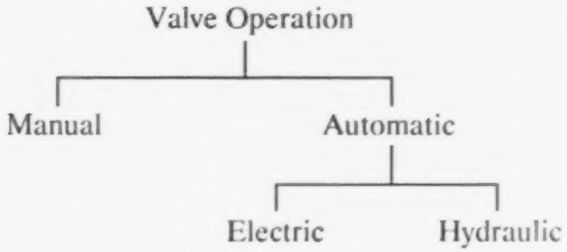


Figure 4-1. Valves Classified By How They Operate

Manual valves

The types of valves vary depending on whether or not they are manual or automatic. Let us look first at the types of manual valves, as shown in Figure 4-2.

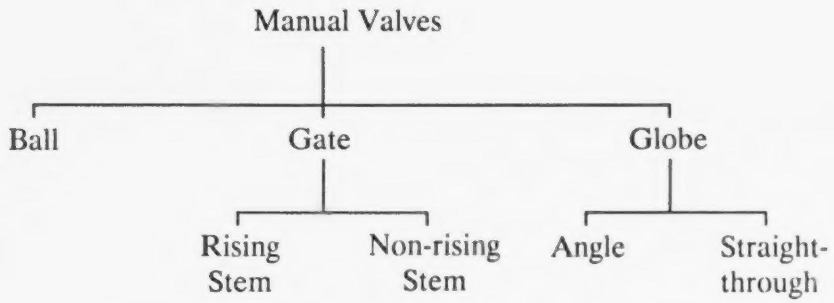

Manual Valves
Ball
Gate
Globe
Rising Stem
Non-rising Stem
Angle
Straight-through

Figure 4-2. Types of Manually Operated Valves

Gate valves and globe valves are discussed in the ABC's of Sprinkler Systems.

A manual ball valve contains a ball on the inside that is connected to a handle on the outside. The ball contains a hole through its center. When you turn the handle to align it with the direction of water flow, water passes through the hole in the ball. When you turn the handle at a right angle to the flow, water cannot pass.

Electric valves

Figure 4-3 show the types of electrically operated automatic valves.

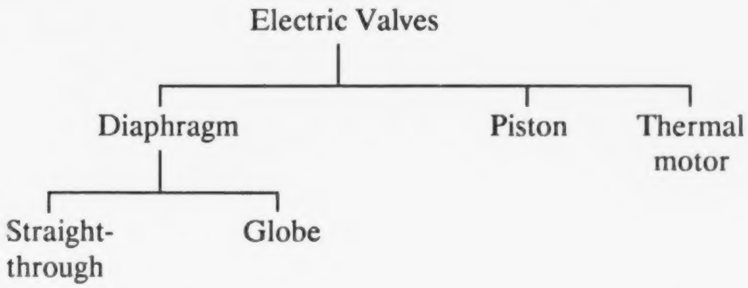


Figure 4-3. Types of Electrically Operated Valves

Diaphragm globe valves, piston valves, and thermal motor valves are discussed in the ABC's of Sprinkler Systems.

The straight-through diaphragm valve functions much the same as the globe-type diaphragm valve. In the straight-through valve, however, the diaphragm raises out of the flow passage and allows the water to flow straight through. With the valve open, you can look through the flow passage. With a globe-type valve, even with it open, you cannot see through it because of a baffle in the flow passage.

Operating current

Most electric valves today operate on 24 volt AC current. In the past, valves requiring 110 volt AC current were used, but such valves are not commonly used any more.

Hydraulic valves

Hydraulically operated valves were once quite common. Today, electrically operated valves have superseded them as the most commonly used valve. Figure 4-4 shows the types of hydraulically operated valves.

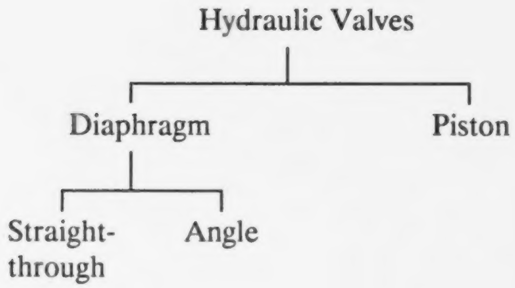

Hydraulic Valves
Diaphragm
Piston
Straight-through
Angle

Figure 4-4. Types of Hydraulically Operated Valves

Additional types of valves

In addition to the types of valves already discussed, you will also deal with other types that are often used in the irrigation business. Figure 4-5 lists the most common of these.

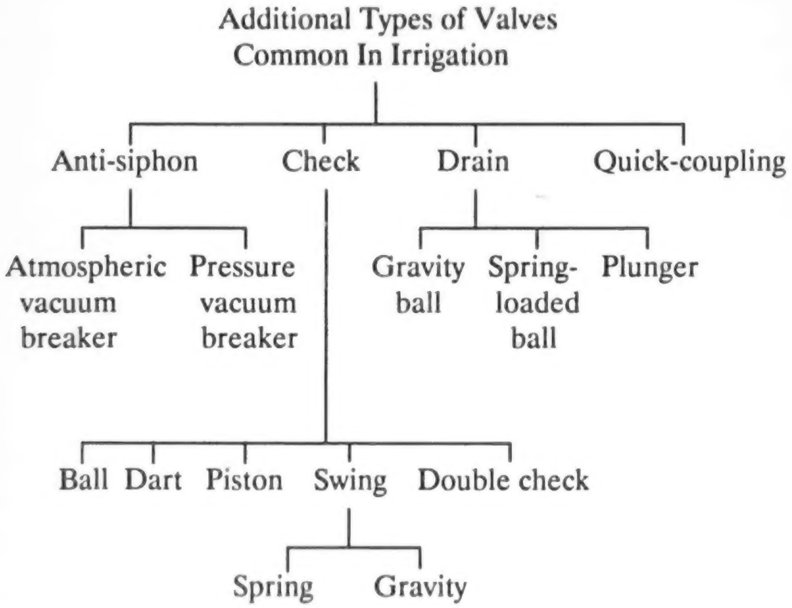

Additional Types of Valves
Common In Irrigation
Anti-siphon
Check
Drain
Quick-coupling
Atmospheric vacuum breaker
Pressure vacuum breaker
Gravity ball
Spring-loaded ball
Plunger
Ball
Dart
Piston
Swing
Double check
Spring
Gravity

Figure 4-5. Additional Types of Valves Common In Irrigation

Notice that anti-siphon valves and drain valves indicate the function they perform. That is, anti-siphon valves prevent backflow and drain valves allow the water to drain from a sprinkler system.

Most of the valves listed in Figure 4-5 are explained in the ABC's of Sprinkler Systems. Discussed below are the ones that are not.

The five types of check valves all work similarly to the swing check valve, which is explained in the ABC's. The name of the valve indicates the type of "clapper" used: a ball, a dart, a piston, or a swinging disk. The purpose of the clapper is to prevent water from flowing backward into the supply line.

The double check valve is discussed in the *Cross Connection Control Handbook* in the appendix of this book

The gravity ball drain valve functions much the same as the spring-loaded ball type. Instead of using a spring, however, the ball is moved away from the drain port by gravity. When the valve fills with water, the flow out of the drain port causes the ball to seat itself on the port and to shut off the flow.

Referring to a valve by its purpose

The purpose that a valve serves in a sprinkler system is often how you will refer to them. For example, we commonly talk about master valves, circuit valves, flow control valves, drain valves, and backflow prevention valves.

You already know about the purpose of drain valves and backflow prevention valves. The purpose of a master valve is just what you would expect--it controls water flow to the entire sprinkler system. A master valve is usually operated automatically.

Circuit valves are the valves that control individual circuits, or groups, of sprinkler heads. The most common circuit valve used today is the electrically operated diaphragm globe valve. Flow control valves can be pre-set at a given rate of flow to regulate flow.

Placing valves

You should always place the master valve at the point where you make the cross connection. This point is most often at the water meter.

Advantages of a manifold

You may place circuit valves in the turf area or connect them to a manifold at a central location. The manifold approach offers a couple of advantages over burying the circuit valves in the turf area. First, all of the circuit valves are easy to find, repair, or replace. Second, you avoid damage, and unsightliness, to the turf area.

Drain valves

Automatic drain valves are an important part of any sprinkler system. You should place them at all low points in the system. Install them at an angle of 30° to 45° below horizontal. If you put them straight down, the valve may clog from debris. If you put them straight across, not enough water can drain from the pipe.

Never install an automatic drain valve at the end of a pipe. Debris can be flushed to the end of the pipe and clog the drain. Move back from the end of the pipe about 12 inches and install the drain valve there.

Always include a sump pit for each drain valve. The size of the sump will vary depending on the type of soil; heavy clay soils require larger sumps. As a general rule, a sump about the size of a one pound coffee can works well. Fill the sump with gravel to ensure good drainage.

Backflow prevention valves

The Febco *Cross Connection Control Handbook* in the appendix of this book discusses where to install the various backflow prevention valves. You may wish to re-read portions of that handbook to review the information.

Opening and closing valves

Automatic valves, whether electric or hydraulic, need some device to open and close them. That device is called a controller and is the subject of our next discussion.

Before you learn about controllers, however, complete the subject review on valves.

Subject Review

Valves

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The more valves used in a system, the fewer ______ per circuit.	
2. Valves bodies today are available in two types of material, both ______ and ______.	
3. A system with manual valves buried at 29" requires a ______ for the property owner to open and close the valves.	
4. Three common ways to operate section valves are ______, ______, and ______.	
5. Valves that ______ and ______ slowly are less likely to cause fatigue in sprinkler components.	
6. Water running through an angle valve always exits at a ______ angle from the direction of entry.	

Statement	Answer
7. Most electric valves require sustained electric current for the valve to remain _____.	
8. A _____ is really any device that can control fluid flow.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. All electric valves are globe type.	
2. Master valves are used to prevent velocities above 7 ft/sec.	
3. Solenoids often use 24 V AC electrical current to close.	
4. The water from the sprinkler system must never be allowed to pass into the cavity above the diaphragm in an electric valve.	
5. Valves need not be sized because they seldom create friction loss.	
6. Anti-siphon valves can be used to regulate flow by partially closing their poppet.	
7. Common backflow prevention devices last many years and do not need to be tested regularly.	
8. Codes usually require that circuit valves be several inches above the highest head in a circuit.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement Answer

1. Most residential sprinkler systems need

   A. Only two valves for the front yard and two valves for the back yard
   B. One master valve, no drain valves, and four circuit valves
   C. An atmospheric vacuum breaker connected to a master valve
   D. As many valves as the water pressure will allow
   E. Both C and D
   F. None of the above

2. You should always place a master valve

   A. Next to a building for protection
   B. Higher than the water meter
   C. At the point where you make the cross connection
   D. On the circuit that has the most sprinkler heads
   E. Both A and B
   F. Both C and D

Statement Answer

3. With a straight-through diaphragm valve open, you

   A. Cannot see through the flow passage because of the baffle plate
   B. Can see through the flow passage
   C. Cannot tell from the outside of the valve if it is open or not
   D. Can tell from the outside of the valve if it is open or not
   E. Both A and C
   F. Both B and D

4. A gate valve with a non-rising stem means that

   A. The valve will not open as fully as a rising stem gate valve
   B. The valve will always wear out faster than a rising stem gate valve
   C. The valve body cannot be removed
   D. The stem swivels in the valve body at a fixed height
   E. The stem can be turned only with a valve key
   F. None of the above

5. Drain valves

   A. Are closed when the valve fills with water
   B. Should be placed at an angle of 30° to 45° below horizontal
   C. Should never be installed at the end of a pipe.
   D. Should always drain into a sump pit
   E. All of the above
   F. None of the above

Statement

Answer

6. Circuit valves

   A. Must be placed in the turf area
   B. May be connected to a manifold at a central location
   C. Must be electric valves
   D. Must be a piston type valve
   E. Must be a globe type valve
   F. None of the above

7. Swing check valves

   A. Allow water to flow in only one direction
   B. Are all spring actuated
   C. Cannot be disassembled for maintenance
   D. Never require maintenance
   E. Both A and B
   F. Both C and D

8. Hose bibbs

   A. Always have an outlet that is 90° to the inlet
   B. Cannot be buried in a valve box
   C. Are often called hydrants or faucets
   D. Always have an outlet smaller than the inlet
   E. Always have a permanent hand wheel for operating the valve
   F. None of the above

Controllers and Electrical Wiring

Controller defined

Within the irrigation business, controllers are often referred to as clocks or timers. But by whatever name, an automatic controller is a device that actuates remote control valves. We refer to a valve and its group of sprinklers as a circuit. Controllers vary widely in the number of circuits they can control, from a single circuit to at least 30.

Types of controllers

The three types of automatic controllers are hydraulic, electro-mechanical, and solid state.

Actually, there is a fourth way to control sprinkler systems: manually. With manual control, of course, a person must physically turn on and off the system. A manually controlled system typically cost less than an automatically controlled one. The inconvenience, however, is a definite drawback.

Hydraulic

Hydraulic controllers are seldom used anymore. Their disadvantages outweigh their advantages. As much as anything, they are victims of the advance of technology. Hydraulic controllers are discussed in the ABC's.

Electro-mechanical

Electro-mechanical controllers use a combination of electronic parts and mechanical parts (such as gears). Watering cycles are turned on and off by means of tripping pins located on a wheel or dial. Such controllers typically have a day wheel and an hour wheel. The pins trip, or turn on, switches as the wheels rotate. This starts the watering cycle, which stays on until the controller timer shuts it off. The cycle then remains off until the wheels rotate around again and the pins once more trip the switches.

For several years, electro-mechanical controllers have been the most widely used. The use of solid state controllers is quickly gaining on them, however.

Solid state

Solid state controllers will undoubtedly become more common than electro-mechanical ones during the next decade. They offer the advantage of being completely electronic. This allows them to have more features than electro-mechanical controllers, as well as to avoid mechanical breakdown.

Table 4-1 summarizes the advantages and disadvantages of the different types of controllers.

Table 4-1. Advantages and Disadvantages of Controllers

Controller Type	Advantages	Disadvantages
Hydraulic	Provided a way to actuate remote control valves before the invention of valves with electric solenoids Not sensitive to surges in electrical power	Can freeze Requires normally open valves Requires clean water to function correctly Leaks in tubing can cause malfunctions Few options and features available
Electro-mechanical	Simple to operate Proven to be reliable Powered by electricity instead of water	Physically large Subject to mechanical breakage Limited programming
Solid State	Powered by electricity instead of water Physically small Flexible programming Several options available Reliable	Sensitive to electrical surges Cost (sometimes)
Manual	Less expensive Can be installed in remote locations where no electrical power is available Allows a visual verification that the system is operating correctly	Inconvenient Not conducive to water conservation (wasteful if operator forgets to shut off system or cannot get to the system for an extended period)

Power requirements

Normally, all three types of controllers require 115 volts AC current for their power. Some controllers operate on the 115 volts. Other controllers change the 115 volts AC to 24 volts. In either case, a common wall socket can supply the power.

The power output from most controllers is 24 volts AC. The output power is used to actuate the valves.

Use an unswitched circuit

Controllers that require 115 volts AC current can be plugged into a wall socket or wired directly. In either case, the current needs to be supplied by an unswitched circuit. This prevents accidentally turning off the controller when a switch is turned off. If you wire a controller directly, always turn off the circuit breaker to that direct line. Remember: you must be a licensed electrician to legally tie into the electrical system and run a direct line.

As a point of caution, remember that the 115 volt input power is polarized. That is, the positive, "hot" wire must be connected to positive and the negative wire must be connected to ground. Polarity is especially important if more than one controller needs to operate from a single power supply.

Electricity and the law

Input power may not always be available at the exact location where you need to mount a controller. A wall of a garage may not contain an electric outlet, for example. In such cases, you must explain the situation to the property owner and request that he or she contact a licensed electrician. Unless you are a licensed electrician, you cannot legally tie into the electrical system to add an outlet or to run a direct line.

Controller features

Automatic controllers are capable of more than just opening and closing valves. The features vary widely with the different types and brands of controllers. Features that are standard on one brand may be optional on another.

Common features

Standard features frequently include an override switch, master valve operation, and pump start. An override switch lets you manually turn off the sprinkler system when watering is not needed, like when it is raining. In fact, some controllers label the switch as a rain switch. The override switch also allows you to start the system manually.

The ability to operate a master valve is an important feature. If a sprinkler system uses an atmospheric vacuum breaker, a master valve is required upstream from the breaker. Also, a master valve is often used to relieve pressure from the manifold and the supply line when the system is not operating.

The ability for the controller to start a pump is another common feature. The water for some sprinkler systems comes from a well or a lake and must be pumped to the system. The pump start feature allows the controller to start the pump at the beginning of the watering cycle and to shut off the pump at the end of the cycle.

Programming

Solid state controllers often have features that are seldom found on the other two types. The most common of these is multiple programming, or the ability to have more multiple watering cycles. This feature is very important because of the increased use of drip irrigation and the fact that different types of plants have different water requirements.

Power backup

Also common on solid state controllers is a battery that provides backup power for the program in the controller's memory. If the electricity is cut off, the battery retains the program until the electricity comes back on. If the electricity were to stay off long enough, the battery would eventually go dead and the program would be erased from memory.

In such situations, many solid state controllers have a built-in program that automatically turns on the system each day, for a brief period, to ensure watering. The built-in program is powered by electricity and will not activate until the electricity is restored.

Surge protection

Because power surges can damage electronic components, surge protection is a another feature often found on solid state controllers.

Actuating the valves

Controllers must have some way to actuate the valves. Hydraulic controllers use water pressure. Electro-mechanical and solid state controllers use an electric charge. The charge is transmitted to the valves through wires.

Fortunately, valves that operate on 24 volt AC current are not polarized. All they require is a "hot" wire and a common wire. You do not have to worry about which wire goes where. You can use the same common wire for all of the valves that the controller actuates. If a system has more than one controller, use separate common wires for each controller.

Electrical wiring

Two types of wire are approved by the National Electrical Code for direct burial: UF and TW. Both types are approved for circuits that operate on less than 30 volts. Type UF contains a heavier insulation than type TW and for that reason is used more often. Check local codes to be certain that the wire you use complies.

Wire gauge

The gauge of a wire refers to its size. Most wire used for sprinkler systems is copper wire of 18, 16, or 14 AWG (American Wire Gauge). The smaller the gauge number, the larger the wire. For example, 14 AWG wire is larger than 18 AWG wire.

The gauge is important because the longer the wire and the higher the amperage requirement, the larger the wire size needed. Most controllers and valves come with documentation that explains their wire requirements, such as the amperage, gauge, and how far you can run the wire. Normally, you can run 18 gauge wire 2000 feet. That distance is the complete circuit, so you could locate a valve 1000 feet from a controller.

Conductor wires

Wire used for sprinkler systems usually contains numerous individual wires within a jacket or sheath. Wire such as this is described by two numbers separated by a slash: 18/8, 16/6, and so forth. The number on the left of the slash indicates the gauge of the wire. The number on the right indicates how many conductors (individual wires) are within the jacket. For example, 18/8 is 18 gauge wire with 8 conductors, and 16/6 is 16 gauge wire with 6 conductors.

Each conductor within the jacket is usually a different color from the other conductors. The white colored conductor is usually used as the common, or ground, wire.

Splicing wire

Try to wire your sprinkler systems without splicing the wire. Run a single piece of wire from the controller to each valve. The reason for this is simple: most electrical problems are caused by bad connections.

When you connect wires, make sure that the ends are clean and secure. Use crimp connectors if the wires will be buried. Taping the wires together or connecting them with wire nuts is not recommended for wires that will be buried.

Always seal a connection regardless of how you make the connection (crimp, taping, or wire nut). A common sealant used in the irrigation business is an epoxy resin type. The resin forms a waterproof seal to protect the connection from moisture.

Installing wire

Leave plenty of slack in the wire throughout the system. Put a loop in the wire at every 90° turn. "Snake" the wire from side to side in the ditch to ensure that the wire has enough slack. At each valve, create a "pig tail" by wrapping about 18 inches of wire around a piece of pipe to curl the wire like a cord on a telephone receiver. Leave additional slack at each connection.

Remember: compared to troubleshooting electrical problems, wire is cheap.

A good place to run the wire as much as possible is under the pipe. The pipe will help protect the wire when you fill in the trench. Handle the wire carefully during the entire installation so that you do not skin off the insulation. A skinned place can allow moisture to enter and can cause grounding problems.

Check the solenoids

Verify that the valve solenoids operate before you bury the wire. Sometimes you can check the operation just with an ohm meter.

Use conduit for any wire that is above ground, even UF and TW wire.

(This page included for duplexing.)

Subject Review

Controllers and Wiring

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The three types of irrigation controllers are electro-mechanical, hydraulic, and ______.	
2. Control valves used with hydraulic controllers may be normally ______ or normally ______.	
3. List three disadvantages of a hydraulic controller ______, ______, ______.	
4. List three functions that you can normally perform with any controller ______, ______, ______.	

Statement	Answer
5. List three functions that are considered extra options on a controller ______, ______, ______.	
6. In the irrigation industry, a controller is usually called a ______.	
7. The two types of wire that can be used under ground are ______ and ______.	
8. If wires will be buried in the ditch, make sure that any splices are ______.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. At most, the number of valves that a single controller can operate is 25.	
2. All controller housings are weather tight.	
3. A totally electronic controller is more versatile than an electro-mechanical controller.	
4. Not all controllers have protective circuit breakers.	
5. The wire to a valve should be pulled fairly tight to prevent the wire from moving in the ditch.	
6. You can use 18 AWG wire on all sprinkler systems.	
7. Wire listed as 18/8 contains 8 circuit wires and 1 ground wire.	
8. Wire that is approved for burial should be enclosed by conduit if the wire is above ground.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The pressure required to operate a hydraulic controller is A. 75 psi or greater B. The number of valves multiplied by .87 psi C. Less than 45 psi D. Equal to or greater than the water pressure in the system E. The number of heads multiplied by .87 psi F. None of the above	
2. The output voltage from most controllers is A. 24 Volts DC B. 24 Volts AC C. 115 Volts DC D. 115 Volts AC E. 220 Volts AC F. None of the above	

Statement	Answer
3. Although it may vary with different brands of controllers, the number of valves that a single station normally operates at one time is A. One B. Two C. Three D. Four E. Six F. None of the above	
4. If electric power is not available at any of the reasonable locations for a controller, you should A. Install an electric outlet in a suitable place, such as a garage, and put the controller there B. Run a weather-proof extension cord from an outside outlet to where you want to put the controller C. Install a manual-start system D. Call a licensed electrician to install an electric outlet E. Inform the customer that a licensed electrician must install an electric outlet F. None of the above	

Statement	Answer
5. Make certain that a controller is connected to A. An outlet that is used only for the controller B. An outlet that has its own circuit breaker C. An outlet that is can be turned on and off by a wall switch D. An outlet that cannot be turned on and off by a wall switch (an unswitched circuit) E. An outlet on an outside wall so that you can get to the wiring if necessary F. None of the above	
6. Regardless of the type of controller used, make certain that you A. Sell the controller under a separate maintenance contract B. Mount the controller where young children cannot easily reach it C. Explain to the customer how to operate the controller D. Both A and B E. Both B and C F. None of the above	
7. The common, or ground, wire is usually A. Red B. Black C. White D. Orange E. The wire largest in diameter F. None of the above	

Statement	Answer
8. A single ground wire can be used as the common wire for a maximum of A. Four valves B. Four valves if the controller is electro-mechanical C. Twelve valves D. Twelve valves if the controller is programmable E. One to six valves F. None of the above	

(This page included for duplexing.)

5. Controlling Water Placement

Section overview

This section discusses the main ways in which water reaches, or is placed at, the locations where watering occurs. First of all, some sort of pipe must convey the water to a location. Once at a location, the water must be dispersed through sprinkler heads and nozzles. Allied with a discussion of sprinkler heads and nozzles is an explanation of precipitation and application rates.

Piping

Pipe defined

Pipe is any hollow tubular material used to convey a fluid. In sprinkler systems, of course, the fluid is water.

The ABC's of Lawn Sprinkler Systems covers the subject of pipe fairly thoroughly. Therefore, this Guide will not dwell on the subject. A few points, however, are worthy of further discussion.

Older pipes may restrict flow

In houses built during the 1930's, '40's, and '50's, most of the supply lines from the water meters into the houses were galvanized steel pipe. Over the years, a certain amount of corrosion can build up on the interior of such pipe and restrict the flow passage.

One form of corrosion can be electrolytic corrosion, or corrosion caused by electrolysis. In simple terms, electrolysis is a chemical change in an object caused by the flow of electrons. A car battery is a good example of electrolysis occurring between different metals and solutions to produce direct current electricity.

Connecting two dissimilar metals together may also cause electrolysis depending on the types of metal. For example, connecting copper pipe to steel or iron pipe can cause electrolytic corrosion of the steel or iron. The way to prevent this is to use a dielectric fitting or other insulation type fitting.

Be aware that if you connect a sprinkler system to an old supply system, you will probably have to deal with restricted flow rates. This make it doubly important for you to check the available flow rate coming from the meter. The most accurate way to do this is with a flow meter, although other methods are available.

Standards

A standard is a comparison against which the quantity, quality, or extent of other items may be measured. For example, the standard measure of a yard is 36 inches. A yardstick 35 inches long would be nonstandard. As you can see, standards allows us to have consistency. Standards also exist for pipe, particularly regarding the size of pipe.

Private industry often originates standards. This can lead to the existence of many different standards and can create a confusing situation. To remedy such confusion, the official representative of the United States for defining standards is the American National Standards Institute, or ANSI.

ANSI was formerly known as the American Standards Association, or ASA. So, when dealing with pipe, you may run across a standards number with a prefix of ASA. (In fact, depending on the time period when the standard was approved, you may also encounter prefixes of NCANSI, USAA, and USAS.)

Effects of temperature on pipe

Temperature affects pipe a couple of ways. First, the temperature of the water affects the pipe. For most sprinkler systems, the working temperature of the water does not vary enough to be a major concern. You will need to use a larger class of pipe if the water temperature in the system is consistently hot (90° or above). The hotter the water, the larger the class number of pipe you should use.

A second way that temperature affects pipe is called thermal expansion. Pipe, particularly all types of plastic pipe, expands when it gets hot and contracts when it get cold. The amount of expansion and contraction can be several inches per hundred feet depending on the type of plastic and the amount of temperature change.

For example, suppose that you installed a 100 foot section of PVC on a July day when the temperature was 100°. After burying the pipe and running cool water through it, suppose that the temperature of the pipe dropped to 50°. The pipe will contract about three inches. If you have not left sufficient slack, the force of the contraction could pull apart fittings.

Water hammer

Impact strength, or the ability to withstand the shock of a blow, is another important characteristic of pipe. Think about the effect of a valve that quickly shuts off the flow of water in a sprinkler system. The water is moving, so it has momentum; the water is also heavy, so it has weight.

The effect of abruptly stopping that water causes a shock called water hammer. Water hammer can actually fatigue pipe and cause it to expand beyond its normal shape. In some cases, the expansion can cause the pipe to rupture.

Make sure that the class of pipe in your sprinkler systems can withstand the surge pressure of water hammer. A rule of thumb is to use the 50% rule. In other words, if the maximum amount of pressure that you expected to encounter is 100 psi, you would want to use at least a class 200 pipe in order to safely allow for surges (50% of 200 is 100).

Another form of water hammer occurs when water that is flowing straight makes a turn. For example, water reaching an elbow fitting actually pushes against the fitting. In some cases, the force is great enough to dislocated the fitting from the pipe. One safeguard against this is a thrustblock, which is some kind of hard material such as a brick, rock, or piece of wood. The thrustblock is placed against the elbow and provides resistance against water hammer.

Effects of sunlight on pipe

Sunlight can deteriorate PVC pipe over a period of time and cause it to weaken. You should store PVC where it is covered and not expose it to direct sunlight for long periods.

Conversely, advances in polymer chemistry have given us polyethylene pipe that can be exposed to sunlight for long periods without harmful effect. In fact, polyethylene pipe is often used for drip irrigation and is made to lay directly on top of the ground. You will learn more about drip irrigation in Section 7.

Connecting pipe

Pipe is connected in various ways depending on the type of pipe. Metal pipe such as galvanized steel is connected with threaded fittings. Connections to copper pipe are usually soldered, or sweated. PVC and ABS connections are solvent welded. Polyethylene pipe cannot be solvent welded. You must use clamp-type fittings instead.

Solvent welding and soldering are so common in the irrigation business that each merits further discussion.

Solvent welding

PVC pipe is connected by a process called solvent welding. The process is called welding rather than gluing because an actual fusing of materials occurs. The solvent softens the pipe and the fitting so that they fuse together when they touch. This is different from a glued connection, which would leave a layer of glue between the pipe and the fitting.

(ABS pipe is also connected by solvent welding. But to simply discussion, this Guide will refer only to PVC. Keep in mind that the same information applies to ABS pipe.)

Before you solvent weld plastic pipe you must cut it to the proper length. A hack saw cuts PVC very well, or you may choose to use one of the cutting tools especially made for cutting PVC. In either case, make sure that all cuts are square and that the ends of the pipe are free from rough edges.

Remove the gloss

The inside of the fitting and the outside of the pipe must be clean and dry. PVC has a glossy coating that you must remove or the weld may not occur properly. You can remove the gloss with sandpaper, but a better method is to use a chemical cleaner or primer.

The cleaner slightly softens the PVC so be careful not to put the pipe and fitting together after you have chemically cleaned them. They will bond enough so that you cannot get them apart, yet they will not be strong enough to withstand water pressure.

Apply the solvent

After you have cleaned the PVC, apply a generous coat of solvent, but not an excessive amount. Apply the solvent to the outside of the pipe and to the inside of the fitting. The distance from the end of the pipe to where you stop applying solvent depends on how far the pipe will fit into the fitting. For example, if the pipe will fit two inches into the fitting, start two inches from the end of the pipe and apply the solvent from there to the end.

After you coat the pipe and fitting with the solvent, push them together and turn one or the other about a quarter of a turn. This evenly distributes the solvent. Hold the pipe and fitting together for 10 to 15 seconds, just long enough for them to make the initial bond, before you proceed to the next connection.

Watch the excess

Be careful not to use too much solvent. Excessive solvent can form a ring on the inside of the pipe and fitting when you push the two together. Since you have no way to get inside and clean off the ring, the solvent will keep softening the PVC and weaken the plastic.

Wipe off any excess solvent from around the fitting. If you do not, the solvent develops a film over itself and will not evaporate. The solvent will then keep softening the pipe at that point and, over time, weaken the pipe.

Use enough solvent to form a good bond, but not so much that you do more harm than good. Keep from dripping solvent on other connections that you are not gluing. Normally, you should wait about 24 hours after solvent welding PVC pipe before you put full pressure on the piping.

Types of solvents

There are several types of welding solvents. Solvents that are referred to as "hot" mean that they soften the pipe quicker and evaporate faster. Take care if you use hotter solvents. Once you apply the solvent, you will need to make the connection rather quickly before the solvent evaporates.

Most welding solvents are flammable and toxic. Use them in well ventilated areas and be careful with open flames around them.

Most of the solvents come in a can with the brush built into the lid of the can. A good practice is to put the lid back on the can every time that you use the solvent. This keeps the solvent from evaporating.

You also need to consider the size of the brush in relation to the size of the fitting. Use a brush that is approximately one-half the inside diameter of the fitting. The brush will hold enough solvent to evenly coat the inside the fitting, but not so much that you end up with excess solvent. If you use a brush too small, it may not hold enough solvent to completely coat the fitting. If you use a brush too big, you will not be able to fit it into the fitting.

Soldering defined

Connections to copper pipe are made by using a combination of heat and a fusible metal alloy. This process is called soldering or, more commonly, "sweating." The heat is usually supplied by a propane torch. The metal alloy is called solder and usually comes on a spool.

Soldering often scares people because they feel it is harder to get a good connection than with solvent welding. But soldering is actually fairly simple provided you use the right materials, follow a few simple guidelines, and do not hurry the process.

About the only time that you will need to solder in the irrigation business is when you connect to a water supply. Some city codes require that a permanent tee fitting be sweated into the line if the building has a copper supply line coming into it. The only way to do this is to solder the tee into place.

We will first discuss soldering and then describe how to fit a tee into an existing water line.

Start with flux and solder

To make soldered connections, you need flux and solder. Flux is an agent that cleans the tarnish off of the pipe and the fitting so that the solder and the copper can bond properly. Use a flux that is referred to as a non-acid or self-cleaning flux. The label on the container will identify the flux as being of this type or not.

The flux removes any chemical barrier that may prohibit a good bond and allows the solder to flow more smoothly. The solder is the actual agent that does the bonding.

Types of solder

When you select a solder, avoid the acid core and flux core solders. Some solders come with a core that has flux or acid in it to clean the pipe. But by the time such solder gets hot enough to actually release the flux or acid, the solder has already melted and is on the pipe. Therefore the flux does not really clean well.

The best type of solder for copper sweating is not available any more, a 50/50 wire solder. The 50/50 refers to the percentage of lead and zinc in the solder, 50% each in this case. The EPA has banned products that contain lead if the products come into contact with potable water supplies. (You may still find 50/50 solder, but eventually it will be removed from the market.)

An acceptable alternative on the market today is referred to as a 95/5. Such solder is 95% tin and 5% antimony. This is a harder solder and is a little more difficult to work with. Nevertheless, it is the best available at this time.

Not all of today's solders are 95/5. Most of them contain a large percentage of tin, but the other 5 or 10% may be antimony, silver, copper, or zinc. Some of these are still fairly easy to work with; any of them will make an acceptable bond.

Add a heat source

The heat required to melt the solder is usually supplied by a small propane torch or an acetylene torch. Use the soldering tip for sweating.

Along with flux, solder, and torch, you need certain safety equipment.

Remember your safety equipment

A pair of gloves is necessary to protect your hands and wrists. The pipe and fittings get very hot when sweated. You also need a pair of goggles to protect your eyes in case the flux or solder pops. Another good idea is to wear a long-sleeved shirt to protect the lower arms. Remember: safety first. Always.

How the bond forms

How is the bond actually made between the fitting and the pipe? When you sweat a fitting, the solder is actually drawn into the void between the pipe and the fitting by capillary action. This is why it is important that they both be really clean and not scratched. You need a smooth, clean surface so that the solder can be drawn in consistently around the joint.

Guidelines for soldering

You will have more success with soldering if you follow a few simple guidelines. These guidelines are presented below. Remember not to rush the soldering process.

Make sure that the pipe and fitting are dry

The pipe and fitting must be totally dry before you solder. Otherwise, the water will keep part of the pipe or fitting from heating. The solder will not stick to that area, and a leak will occur there.

Because you will usually be sweating a water line, some amount of water will be in the line. Even after you drain the line, a small amount of water may still be in the bottom of it and come trickling out for a long time.

The pipe and fitting must be dry, yet water is always present. What do you do? Bread. Take a slice of bread, remove the crust, and form the slice into a ball or oval. Push the bread up the pipe about 2 or 3 inches back from where you will solder.

The wad of bread will temporarily stop the flow of water. You can then make your solder connection. The bread breaks down completely and will not plug up the line. When you turn the water back on, open a hose bibb to flush out what is left of the bread. Remember to open a hose bibb and flush out the remnants of the bread. Let the water flow out of the bibb for 2 or 3 minutes to thoroughly flush the line.

Clean the pipe and fitting

Always work with a clean pipe and fitting. You need to remove any dirt and grim, as well as any filings that may be left from when you cut the pipe. You can clean the pipe after a cut with fine emery cloth or sandpaper.

Be careful not to use an emery cloth or sandpaper that is course enough to roughen the surface. The surface must be kept smooth. Any scratches or grooves on the surface can hinder the actual bond.

Use flux

Before you solder, coat the fitting and the pipe with flux. The flux cleans the copper and helps the solder to flow smoothly and evenly. Flux is usually applied with a brush. Apply an even coating, but not excessive, to the inside of the fitting and the outside of the pipe.

Slide the connection together and rotate it to make sure that you spread the flux evenly. Once the fitting is together and rotated, turn the fitting to the correct position and you can start the soldering.

Apply the heat to the fitting

Always heat the fitting, not the pipe. The fittings are normally of a heavier construction than the pipe. If you heat the pipe, it may get too hot before the fitting has a chance to heat thoroughly. This situation can cause inconsistent heat around the connection and create a bad solder connection. Heat just one side of the fitting; do not try to move the torch around and heat the entire fitting.

Normally, you can heat a fitting in 7 to 10 seconds. You will be able to tell when the fitting is hot enough because the flux will start to bubble and pop as it melts. You can scorch a fitting if you heat it too long. A fitting usually turns a blue color if it is overheated. If the fitting stays blue after it has cooled off, you should replace the fitting. Solder will not stick well to a scorched fitting.

Once you see the flux starting to bubble, apply the solder to the opposite side of the connection. If the solder sticks and does not melt immediately, pull it away and heat the fitting for another 2 or 3 seconds.

Just as soon as the connection is hot enough to melt the solder, remove the heat from the fitting. Apply the solder right at the joint where the pipe and the fitting come together.

The solder will spread naturally around the joint and be drawn into the void between the pipe and the fitting.

Apply solder opposite the heat

Always apply the solder to the side of the connection opposite the heat. That makes sense when you think about it: if the side opposite the flame is hot enough to melt solder, the side toward the flame certain is. The reverse may not be true.

A good practice is to heat the upper part of the fitting on one side and apply the solder on the lower side across from the heat. You can be fairly certain of a good solder joint if you can draw the solder up and around the fitting. Regardless of where you apply the heat, however, make sure that the solder draws completely around the fitting.

Tips on handling the solder

Normally, you need about the same amount of solder wire to make a connection as the size of the pipe's outside diameter. That is, a 1/2 inch pipe normally requires about 1/2 inch of solder wire; a 3/4 inch pipe normally requires about 3/4 inch of solder, and so forth.

Just after you apply the solder, wipe off the joint with a soft cloth. This removes any excess solder and smooths out the sweated joint. Any solder left on the outside has nothing to do with the actual solder connection. It is just extra and should be removed (for looks more than anything).

A good way to handle the solder is to take about 18 to 24 inches off of the roll. Do not try to work with the entire roll. Wrap about half the length around your hand to make sort of a coil.

This gives you something easy to hold, yet it is a small enough piece that you can easily work with it.

Tips on soldering several fittings

When soldering several fittings, you need to start with the lowest one and work your way up. That way, any excess solder from a fitting will not drip on one that you are getting ready to solder. Also, if you have several fittings to put together, go ahead and clean them, put the flux on, and assemble the whole thing before you start soldering. Then you can come back and solder all of the fittings.

Soldering all of the fittings at one time can speed up the job. A certain amount of the heat applied for the first fitting heats the next fitting, and so on.

Resoldering a fitting

If you need to resolder a fitting, heat it and remove it from the pipe. Remove any solder that is on the pipe or fitting and reflux them both. You must reflux if you resolder, or the connection will probably be faulty.

Watch out for flammable backgrounds

If you are sweating a fitting against a wooden wall or something that is flammable, you need to slide a piece of tin or some protective barrier between the fitting and the flammable substance. Remember that the heat from the end of the torch extends quite a bit farther than the actual flame. Be careful not to burn yourself or ignite something.

The hottest part of the flame is at the end of the blue part of the flame. Normally, on a well adjusted torch, the blue part is about a quarter of an inch long.

Connecting plastic to copper

In some cases you may need to connect plastic to copper, such as coming off of a copper tee with a PVC line. The PVC connection needs to be a threaded fitting. Special adaptors are available that have a sweat fitting on one end and threads on the other end. Be sure to solder the adaptor in place before you connect the PVC to it. Otherwise, the heat from the soldering may damage the threads on the PVC. Wait until the adaptor has cooled completely before connecting the PVC.

Connecting a tee to an existing water line

The types of copper pipe commonly used for water lines are fairly soft. When you dig a hole to reach the water line, be careful not to hit the pipe with the shovel--you may scar or flatten the pipe. The pipe needs to be round and unmarked to help ensure a leakproof connection.

Select an area of pipe that is round and unmarked about 8 to 10 inches long. This is where you will connection the tee.

Use a tubing cutter or hack saw and remove about a 6 to 8 inch section of the pipe. Remove any burrs from the ends of the pipe.

Using a no-stop coupling

Because the copper pipe is fairly rigid, you will not be able to simply replace the cut-out section with a tee fitting the same length. Instead, you need three pieces to install a tee: the tee fitting itself, a short piece of copper pipe the same outside diameter as the water line, and a no-stop coupling.

A no-stop coupling does not have a ridge on the inside for the pipe to butt against. The coupling can slide completely on the pipe.

Clean and flux the fittings and pipe. Slide the no-stop coupling onto the existing water line, flush with the end of the line. Push the tee onto the other exposed end of the water line. Add the small piece of pipe to the other end of the tee. Now slide the no-stop coupling onto the short piece of pipe until the coupling overlaps the short piece and the water line about the same amount.

This arrangement leaves you 4 joints to solder: 1 on each side of the tee, and 1 on each side of the coupling. You can then sweat all 4 joints in sequence and complete the water connection.

Intermission to change the pace

Before you read about the next subject, sprinkler heads and nozzles, complete the subject review on piping and connecting pipe.

Subject Review

Piping and Connecting Pipe

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement　　Answer

1. Three main types of thermoplastic pipe are ______, ______, and ______.
2. With PVC 1120 pipe, the first "1" refers to the ______, the second "1" refers to the ______, and the "20" refers to the ______.
3. The stretching of plastic pipe by over-pressuring is called ______.
4. A type of pipe that is flexible, comes in rolls, and is resistant to freezing is ______ pipe.
5. The term used for the comparative reference of different sizes of pipe is the ______ pipe size.
6. 50/50 wire solder is no longer available because it contains ______.
7. Solder is drawn into the joint because of ______ ______.
8. The two materials needed to sweat a joint are solder and ____.

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Electrolysis may occur when two dissimilar metals are joined.	
2. I.P.S. refers only to metal pipe.	
3. An installation process that allows for the pipe to expand and contract is called "snaking."	
4. The force that develops when valves quickly close is called water hammer.	
5. An installation device that helps cushion pipe elbows against water hammer is called a thrust block.	
6. PVC 2210 pipe has a design tensile strength of 2000 psi.	
7. All PVC solvents are the same.	
8. PVC solvent can also be used to weld polyethylene pipe.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement

Answer

1. The official representative of the U.S. in the field of international standards is

   A. ASTM (American Society of Testing and Materials)
   B. AWWA (American Water Works Association)
   C. ANSI (American National Standards Institute
   D. AAIS (American Association for International Standards)
   E. USSA (United States Standards Association)
   F. None of the above

2. The term "schedule" refers to

   A. The wall thickness of iron pipe only
   B. The wall thickness of PVC pipe only
   C. The O.D. and wall thickness of all pipe materials, based on the O.D. and wall thickness used in steel pipe
   D. The I.D. and tensile strength of all pipe materials
   E. The O.D. minus the I.D.
   F. None of the above

Statement	Answer
3. The wall thickness of a pipe may be determined by A. O.D. - I.D. B. (I.D. + diameter)/2 C. (I.D. + radius)/2 D. (I.D. x 2) - O.D. E. Both C and D F. None of the above	
4. The letters which designate copper tube size are A. A, B, S B. P, V, C C. J, K, L D. K, L, M E. S, M, L F. L, S, M, F, T	
5. Continuous water hammer and surges can cause A. Hydrostatic design stress B. Hydrostatic pressure vacuum C. Pipe fatigue D. Pipe electrolysis E. Both A and B F. None of the above	

Statement	Answer
6. The term "class" refers to the A. Design tensile strength of pipe B. Design tensile strength of fittings C. Design working pressure of pipe D. Design process of pipe extrusion E. Impact strength of pipe F. None of the above	
7. A good sign that the fitting is ready to take solder is A. The fitting will turn a bluish color B. The fitting will turn a reddish-orange color C. The fitting is hot to the touch D. The flux bubbles and pops. E. The solder sticks to the fitting F. None of the above.	
8. To solder a 1/2 inch fitting should take approximately A. 4 inches of solder B. 2 inches of solder C. 1 inch of solder D. 1-1/2 inches of solder E. 1/2 inch of solder F. None of the above	

(This page included for duplexing.)

Sprinkler Types and Nozzles

Sprinkler head defined

So far in this Guide, you have learned about connecting to the water supply and conveying the water through pipes to various locations. Once you get the water distributed, you need some way to disperse it. This is the purpose of the sprinkler head. A sprinkler head is a device that connects to the piping for the purpose of dispersing water.

Actually, the sprinkler head itself is usually a housing, or container, for a nozzle. The nozzle is the component that dispenses the water in a specific pattern and distance. Two terms that you will see associated with nozzles are trajectory and arc. Trajectory is the angle from horizontal at which the water stream or spray or flow leaves the nozzle. Arc is the portion of a circle that the water covers. For example, a half-circle arc is 180°.

In common terms, the two basic categories of sprinkler heads are rotary heads and spray heads.

A rotary head disperses water while rotating. A mechanism--usually a water-driven mechanism--rotates a nozzle over a given arc. The three most common types on the market are the impact head, also called impulse head, the gear drive head, and the ball drive head.

Because the ABC's of Lawn Sprinkler Systems discusses the types of rotary heads quite thoroughly, this Guide will not dwell on them. A few points about rotary heads do merit further discussion.

Application of rotary heads

Rotary heads are usually used to water large turf areas, which most commonly means commercial applications. The heads may be placed in the turf area itself, or along the edge and throw water into or across the area. In either application, one advantage of rotary heads is their large radius of throw to cover such areas. Another advantage is that a system with rotary heads usually costs less than a comparable system with spray heads. The rotary heads cost more per head, but it takes fewer of them to cover an area.

Some drawbacks

The disadvantages of rotary heads is that they are sloppy and wasteful. To cover such long distances, rotary heads throw water high into the air. The water has more contact time in the air and is more susceptible to wind deflection and evaporation. In short, rotary heads are not efficient in conserving water.

Another disadvantage of rotary heads is the limited amount of adjustment to reduce their radius of throw. This, combined with the fact that rotary heads throw only circular patterns, limits their usefulness almost entirely to large, open areas. Trying to use rotary heads in areas with obstructions such as buildings, walls, streets, sidewalks and parking lots, will invariably mean that you throw water into places that may prove objectionable.

Operating pressures

Rotary heads, just like spray heads, have a minimum operating pressure, and usually a maximum operating pressure. The heads operate most effectively in the range between the minimum and the maximum pressure. Pay very close attention to the manufacturer's specifications on heads. Rotary heads have vastly differing operating ranges depending on the type of head. Some may require 60 or 70 psi, or more, to work properly; others may operate just fine at 20 or 25 psi.

Water distribution with impact heads

Impact heads distribute water unevenly because the nozzle assembly "jumps" with each impact. The "jumping" results in a jerky movement so the water is not applied evenly.

Also with most impact heads, the precipitation rate changes as you adjust the arc down (from 180° to 90° for example). The discharge rate remains the same, however. The discharge rate is how much water per minute exits the nozzle or the head. (Some types of rotary heads do allow you to decrease the discharge rate as you decrease the arc.)

Precipitation rates and discharge rates are discussed further at the end of this section.

Interestingly, ball drive heads are actually impact heads--the spinning ball impacts an "anvil" and thus rotates the nozzle assembly. A ball drive nozzle typically rotates more smoothly than an impulse nozzle and therefore distributes water more evenly.

Gear drive heads

From the name, the gear drive head is somewhat misleading. The head is driven by a turbine or water wheel. The spinning action of the turbine is then reduced through a series of gears (much like a transmission in a car). The gear mechanism rotates the nozzle very smoothly. The smoothness of rotation allows the gear drive head to distribute water more evenly than other types of rotary heads.

Spray heads

Spray heads are the other common type of sprinkler heads. Spray heads typically have a nozzle with a fixed orifice that is machined or milled. The size of the orifice, as well as how it is machined or the angle at which it is cut, determines the arc of the throw, the trajectory of the throw, and the discharge rate of the head.

The discharge rate is how much water per minute exits the nozzle or the head. Some spray heads have a flow adjustment, usually a valve, that you can adjust with a screwdriver. The adjustment is commonly located at the nozzle and allows you to vary the radius of throw.

Spray heads vary in their trajectories and arcs of throw and their discharge rates. Most spray nozzles are available in trajectories from 0° to about 40°. The arcs vary from the most common, 360° or a full circle, down to about 20°. The various arcs, or spray patterns, help you to irrigate oddly shaped areas.

Discharge rates vary greatly among spray heads, just as they do among rotary heads. Always check the manufacturer's specifications when determining discharge rates.

Shrub heads

One common application of spray heads is for watering shrubs and flower beds. Obviously, to disperse the water past obstructions, shrub heads needs to be higher than the shrubs. This is accomplished by raising the shrub head above the ground on what is called a riser (typically a piece of PVC or copper).

Risers have a couple of disadvantages. First, they are a hazard if anyone should trip on one or fall on one. For this reason, you should always place them against a fixed wall or structure. Second, they need to be higher than the shrubs. But shrubs may easily grow above the height of the risers. Fortunately, an extremely effective and efficient alternative to risers exists. Section 7, Drip Irrigation, discusses it.

Disadvantages of spray heads

The main disadvantage to spray type nozzles is just that--they spray. This usually limits the useful radius of throw to about 15 feet. Also, many spray heads distribute water in a doughnut shaped pattern. This means that they leave a dry area near the head itself. The patterns of spray heads must be overlapped to correct the problem.

Another disadvantage of spray heads, which is actually a problem of incorrect design, is that they are often easy to over-pressurize. This condition causes a very distinct atomizing effect on the water leaving the nozzle and produces a fog or fine mist.

In fact, the main design factor that affects sprinkler operation is pressure. Too much pressure not only causes a head to perform poorly, it can actually shorten the operating life of the head.

If you do operate a spray nozzle at an ideal pressure, the nozzle will produce droplets of water. But the droplets are so small that they still susceptible to wind deflection and evaporation.

Controlling water placement with spray heads

It may seem economical to use heads that cover a large radius and therefore use less heads. In actuality, such a decision may be false economy. The loss in water will probably, in the long run, exceed the cost of the additional heads.

Using more spray heads also gives you more control of water placement. Typically, the shorter the distribution radius of the head, the more control you have of where the water lands. Some spray nozzles have an adjustment on them that is usually located right at the nozzle. The adjustment allows you to decrease or increase the radius of the throw by regulating the amount of water through the nozzle. But when you adjust the water at the place where it exits, what you actually do is distort the pattern of the head itself. This is a distinct disadvantage.

Hybrid spray heads: stream rotor and wobbling nozzle

Two types of spray heads could be classified as hybrids. One type is the stream rotor, which ejects water in a number of small streams from a pop-up nozzle. These heads have an internal mechanism that gives you some of the effects of a rotary head and some of the effects of a spray head. Often the mechanism is a turbine type gear drive that rotates an internal nozzle.

These heads were developed for use in places where runoff is a major problem. For example, areas that have steep slopes and very nonporous soil would cause run off. If you use this type of head, remember to put them on their own circuit, separate from other heads. The reason is that they have a low precipitation rate, much lower than regular spray heads. You should also overlap stream rotors head-to-head.

Wobbling nozzle

The other type of hybrid is really not a spray head at all even though it is commonly listed as such. This type of head has a pop-up piston with a nozzle in it. The nozzle itself moves--it both spins and pendulates, or wobbles. The moving nozzle is similar to a rotary head, yet the water going in all directions at once is similar to a fixed orifice spray head.

The main advantage of this type of head is that the wobbling action distributes water better than from a spray or a rotary head. In addition, the wobbling action and internal nozzle design breaks up the water into droplets which are less susceptible to wind deflection and evaporation. This type of head is mentioned on page 15 in the ABC's.

Precipitation

Precipitation and precipitation rate are of utmost importance to an irrigator. Precipitation is the amount of water applied over a given area. The amount of water is measured in inches (or some unit of depth such as millimeters). For example, suppose that you have a flat, waterproof box 20 feet square. If it rained 1/2 inch and you took a ruler and measured the depth of the water anywhere in that box, it be 1/2 inch. (The box could be any size and this would still be true.) Your box received 1/2 inch of precipitation.

Precipitation as applied by an irrigation system should be looked at in exactly the same terms. In other words, you can easily calculate precipitation if you know the volume of water used and the area over which you applied it.

Precipitation rate

Precipitation rate is a measurement of how rapidly a sprinkler head or a sprinkler system applies water. The rate is defined as depth of water per some unit of time. Usually, it is expressed in inches per hour.

Discharge rate and precipitation rate

Discharge rate is how much water per minute exits the nozzle or the head. You cannot simply relate precipitation rate to the manufacturer's discharge rate of the head. The discharge rate is usually calculated within the range of proper operating pressures.

Operating pressures outside of the proper range will change the discharge rate (the greater the pressure, the greater the discharge rate). Also, the discharge rates change over time. Older heads may have a certain amount of washout; the orifices may have grown larger from water erosion. The piping may develop constrictions or corrosion, or may become partially clogged by solids in the water.

In addition, the discharge rate does not take into account overlapping. In general, circular pattern heads, spray or rotary, are overlapped 50% of the diameter. Said another way, that amount of overlap is radius-to- radius or head-to-head.

With such overlap, some areas will be covered by 1 head, other areas by 2 heads, and still other areas by 3 heads. The amount of precipitation varies depending on the amount of overlap.

Figuring precipitation rate

One inch per hour is a number often claimed to be a normal precipitation rate for most conventional, fixed orifice spray heads. For the reasons just discussed, you can see that such a number is essentially useless except for initial design estimates.

The only reasonable way to calculate precipitation is to compare the total volume of water applied to the actual area of landscape or turf watered.

The most accurate way to measure the amount of water applied is to install a flow meter in the system. Sometimes you can use the water meter for this if it is legible and operates properly. Formulas also exist for calculating precipitation rate, but they tend to be approximations. If you are interested is such formulas, consult product documentation from various head manufacturers or reference books such as the Turf Irrigation Manual.

Plants and precipitation

Why fuss with precipitation and precipitation rates anyway? Because different types of plants have different watering needs. You need to apply the proper amount of water for the type of plant life being irrigated. Otherwise, your system is less efficient and you waste water and the customer's money.

Determining the correct precipitation for different plant types takes some research on your part. A variety of sources exist where you can get information: county extension agents, the National Weather Bureau, nurseries, garden clubs, and books (bookstores and public libraries), for example.

The research is worth the effort, however. Remember the discussion in Section 1 about your becoming a professional irrigator and not just "someone who installs sprinkler systems." Part of being a professional irrigator is to know about the watering requirements of the plants common to your locale. With modern irrigation products and technology available to you, guessing about the amount of precipitation being applied is unacceptable.

Precipitation rate and heads on a circuit

Precipitation is also important because you need to put heads with similar precipitation rates on the same circuit. This allows the circuit to cover a given area with a consistent amount of precipitation.

Rotary heads typically have a much lower precipitation rate than spray heads because at the same discharge rate they cover a much larger area. For that reason, you normally do not want to put rotary heads on the same circuit with spray heads. Precipitation rates over a given circuit should be the same unless you are tailoring certain parts of that circuit to apply less water to certain areas. This would make the design process very complicated, however, and usually less accurate.

Onward and upward

Now that we have discussed sprinkler heads and nozzles, complete the subject review on the next few pages.

Subject Review

Sprinkler Heads and Nozzles

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The main design factor that affects sprinkler operation is _____.	
2. In common terms, the two major categories of sprinkler heads are _____ and _____.	
3. The most common types of drive mechanisms for rotary heads are _____, _____, and _____.	
4. The drive mechanism for so-called "gear-drive" heads is actually a _____.	
5. When you design a system that has different types of heads, with various shapes and sizes of spray patterns, always take into account the _____ rate of the heads.	

Statement	Answer
6. Conventional spray heads discharge a flat pattern of spray that is usually ______ in shape.	
7. Some sprinklers distribute water more efficiently by means of a moving nozzle which creates a ______ action.	
8. A system with rotary heads is generally less ______ than a system with lawn or spray heads.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Generally, the greater the distance water is thrown, the more it is affected by wind.	
2. If a turf area is quite large and you have enough water supply, you should use the largest radius rotary heads available.	
3. Ball and cam drive heads are, in effect, impact heads.	
4. All fixed orifice spray heads distribute water very evenly within the pattern.	
5. For the same area, a well designed system with rotary heads can be just as water efficient as a well designed system with spray or sprinkler heads.	
6. With most impact heads, as you adjust the arc down (for instance, from 360° to 180°), the precipitation rate remains the same.	
7. With most impact heads, as you adjust the arc down, the discharge rate remains the same.	
8. Some lawn sprinkler heads have nozzles that pendulate or wobble to improve water distribution within the pattern.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The application for rotary heads is A. For the cheapest system possible B. For large turf areas C. For small, mostly square yards D. For mostly square yards with no trees E. For flower beds F. None of the above	
2. Lawn heads are more efficient than rotary heads because A. They are usually less affected by wind B. They waste less water C. You can fit them into odd shaped areas more efficiently D. They cost less E. A, B, and C F. A, B, and D	

Statement	Answer
3. Shrub heads on risers A. Should be on both sides of a flower bed to distribute water evenly B. Must be made of copper or brass because the riser is above ground C. Can be a hazard and should always be placed against a fixed wall or structure D. Should be higher than the height of the shrubs F. Both C and D E. Both A and B	
4. Water pressure that is too high for a sprinkler system A. Is a major cause of water waste because the heads perform poorly B. Can shorten the operating life of the heads C. Gives a little extra distance of throw and thus improves water distribution D. Is generally okay because the heads pop up to their full height E. Both A and B F. Both C and D	

Statement	Answer
5. Never include rotary heads and sprinkler or spray heads on the same circuit because A. They look unsightly together when they operate B. Determining the spacing for good overlap is very difficult C. The precipitation rates are greatly different D. The discharge rates are greatly different E. Both A and B F. Both C and D	
6. The reasonable way to calculate precipitation is A. To know the discharge rates of the heads B. To know how long the system has been running C. To know the distribution profile of the heads D. To know the actual volume of water applied and the actual size of the area to which it was applied E. Both A and B F. Both C and D	

Statement	Answer
7. Trajectory is important to the irrigator because A. Generally, the higher the throw, the greater the radius B. The higher the throw, the better the water distribution C. The higher the throw, the more water lost to wind D. The higher the throw, the more water evaporation E. Both A and B F. Both C and D	
8. All conventional circular pattern spray heads A. Throw large drops of water B. Have the same operating pressure range C. Must be properly overlapped to improve water distrubtion D. Have a constant discharge rate regardless of water pressure E. All of the above F. None of the above	

(This page included for duplexing.)

6. Layout and Design

Section overview

Layout and design involves much information that is central to the irrigation business. This section is fairly lengthy and at first may seem overwhelming. Remember, however, that you are building your understanding one piece at a time. As you progress through the areas in this section, the entire subject of layout and design will make more sense.

The layout and design of sprinkler systems can be looked at as involving 4 main phases:

1. Drawing an accurate plot plan.
2. Laying out the sprinkler heads on the plot plan.
3. Sectioning the sprinkler heads (adding the plumbing).
4. Checking your design mathematically.

Before discussing each phase, however, we need to cover some general information about layout and design. This information discusses the basics of design and of hydraulics. Following that, the 4 main phases are then explained.

Design Basics

When a customer wants the least expensive system

Your goal is to design a system properly and according to good irrigation practices. But you also have to comply with what the property owner wants.

Many times you will encounter a property owner who wants the least expensive system. The least expensive system is seldom, if ever, the most effective and efficient system. The customer needs to know this.

For example, a system that throws water across sidewalks and driveways will probably be less expensive than one that does not. But over the years, the customer may actually spend more on water than on the cost of a more efficient system. In addition, watering sidewalks and driveways does not promote water conservation.

A better approach to serving the customer's needs is to offer a choice. Design the most efficient and effective system based on the requirements of the customer and on good irrigation practices. Be prepared to support your design when you present it to the customer. Always explain to the customer the design and how the system will operate.

Remember that as a professional irrigator, you promote good irrigation practices. Wasting water is not one of them. Design your systems with good irrigation practices in mind. Most customers will recognize that your design is professional and is not priced merely for more money.

If necessary, but only if necessary, you can adjust the design to lower the total cost of the system. You need to find that balance between the best possible system and one that the customer can afford. Ideally, they are the same.

Installation and Design

The installation of the system may not exactly match the design. Sometimes you must make on-the-job alterations. Try to keep the installation and the design as identical as possible, however. Note any alterations on the design.

Always leave a copy of the design with the customer. He or she needs to know where the system components are located. The design is also helpful if another irrigator needs to perform maintenance on the system at a later date.

Precipitation rate revisited

You learned about precipitation rate in the last section. But a discussion about design basics is another good place to mention it. Remember that precipitation rate measures how much water is applied to an area and how rapidly.

The precipitation rate for each circuit can be calculated. One way to do this is listed on page 91 in the ABC's. You will understand each part of the formula more fully by the time you finish this section.

The formula calculates the rate for triangular spaced spray heads. Other formulas exist; some even take into account full-circle sprinklers and part-circle sprinklers on the same circuit.

Calculating the precipitation rate of individual sprinklers, or circuits, is a way to know how quickly water will be applied to the landscape. For instance, suppose that you calculated the precipitation rate on a circuit to be 1/2 inch per hour. If you ran that circuit for an hour, the amount of precipitation would be the same as if it had rained 1/2 inch in an hour's time.

Precipitation rate and controllers

You need to know the precipitation rates of the various circuits to determine how long each circuit should water. You can then apply the rates when you explain to the property owner how to set the length of watering times on the controller.

Knowing the rates is your basis for knowing how long to set the watering times. The property owner can then understand each circuit in terms of "so many minutes" equals "so many inches of rain."

Other factors, such as the type of soil and slope of the land, also affect watering times. Consider such factors when you determine watering times; do not rely totally on the calculation of precipitation rate.

Drawing practices

Use common sense in the drawing practices for your designs. For example, use a half circle to show one pipe crossing another. Use short lines at intersections to show the fittings. Elbows should have two short lines; tees should have three.

The following symbols are commonly used in the irrigation business:

Ⓜ = Water meter
—⋈⋈— = Backflow prevention device
⊙ = Section valve
— — — = Main line piping
——— = Section piping
● = Grass head
○ = Shrub head

Your drawings should always be drawn well enough to prevent confusion about the layout and design.

Problem: low static pressure

If the static water pressure is 30 psi or less, you may not have enough pressure to operate a sprinkler system. Let us look at why.

Many types of spray heads have a minimum operating pressure of about 20 psi. This means that all of the spray heads--even the last head on the farthest circuit--must get 20 psi to operate correctly. If you have only 30 psi to start with, you can afford to lose only 10 psi before water reaches that furthest head. Depending on the route, the water may lose more than 10 psi before it reaches the last heads.

Use a larger supply line

A reasonable and economical way to reduce the amount of pressure drop is to use a larger size pipe for the supply line.

Tie into the water line with a tee fitting as close to the water meter as possible. This helps prevent any further pressure loss by running unnecessary pipe. From the tee, you use a larger supply line. A good irrigation practice that is commonly followed is to upsize the pipe at least one size from the size of the meter.

For example, if you connected your tee to a 3/4 inch line, you would use a 1 inch supply line. In some cases, you may even need a 1-1/4 inch supply line depending on the water pressure and the amount of pressure loss.

A larger supply line is a good way to improve the flow and decrease the pressure loss.

Problem: static pressure too high

A static pressure that is too high can also cause problems with a sprinkler system. Possibly the most prevalent mistake that irrigators make is to install systems that are over pressured. The reason that many spray heads mist and fog is because of too much pressure at the head.

Sprinkler heads have an ideal operating range of pressure (often from 20 to 35 psi). If the pressure exceeds that range, the operation and the longevity of the heads suffer. Over pressurizing occurs all too commonly. As irrigators, we tend to look at having high pressure as a good thing for a variety of reasons. (You need fewer sections, valves, pipes, etc.) But keep in mind that too much pressure can reduce the effectiveness of a system.

Use a pressure regulator

A common remedy for high pressure are pressure regulators. A variety of types exist, including pressure-regulating valves. The regulators are fairy expensive, but they greatly prolong the life of a system.

Basics of Hydraulics

Hydraulics defined

In irrigation, hydraulics is the study of the motion of water. You need to have a working knowledge of hydraulics in order to correctly design irrigation systems. Fortunately, much of the information concerning hydraulics exists in charts and tables. Most of your calculations require only simple math.

Moving water

For all practical purposes, water cannot be compressed. Therefore, a mechanical force -- pressure-- is required to move the water. The pressure may come from a pump or from the weight of the water itself.

In the irrigation business, pumps are most commonly used on large commercial installations. The pumps are usually the centrifugal type.
Regardless of the type, however, no pump can draw water upwards more than 33.94 feet. You would typically want to install a pump no more than 15 or 20 feet above a water source.

Many areas get their water from elevated storage tanks (water towers). The weight of the water produces the water pressure. Water weighs 8.34 pounds per gallon. One cubic foot of water weighs 62.37 pounds. The higher the tank, the more water pressure at ground level.

Water pressure is something that irrigators are concerned with in the design of systems. The different parts of a system have different pressure requirements.

Measuring pressure

Pressure is measured in pounds per square inch (psi), or in feet of head. Pounds per square inch is the force that is produced by the weight of the water on 1 square inch of area. For example, the weight of 1 foot of water acting on 1 square inch is .433 pounds. Therefore, 1 foot of head (height) equals .433 pounds per square inch.

If you increase the height of the water to 2.3 feet, the weight acting on 1 square inch is 1 pound. (2.3 feet X .433 psi/foot = 1 psi). Therefore, 1 psi equals 2.3 feet of head. Feet of head is further explained in the ABC's.

Static pressure and working pressure

The amount of water pressure when the water is not moving is called static pressure. You design a sprinkler system initially based on the static water pressure. As you progress further with the design, you must deal with what is called working pressure. Working pressure involves water that is moving.

The working pressure will always be lower than the static pressure. Just as soon as water starts moving, it loses pressure. You have only so much static pressure to work with. Once the pressure is lost, you cannot regain it. (Remember, water pressure may come only from a pump or from the weight of the water itself.)

Friction is the reason that moving water loses pressure.

Friction

Friction occurs when two objects rub against each other. Water flowing through a pipe, for instance, rubs against the walls of the pipe. Friction exists between the walls of the pipe and the water.

Friction also occurs when the water changes directions. For example, friction occurs when water passes through a meter, a backflow prevention device, or even a valve.

The ABC's explains friction quite well on pages 95 through 98, and introduces the term "friction loss."

Friction loss

The effect of friction is to slow down the water. This is the same result as if you were to decrease the pressure on the water. Therefore, friction loss is also called pressure loss. The two terms are used interchangeably.

Every type of sprinkler head has a minimum operating pressure. It is the least amount of water pressure required for the head to operate correctly. Any amount less, and the head may work incorrectly or not at all. So you can see why working pressure is so important to a design. You will learn about calculating working pressure later in this section.

An important thing to remember about irrigation hydraulics is that there is a difference between static pressure and working pressure.

Velocity

Velocity is often confused with pressure. Velocity is the speed at which the water is moving in a system. Pressure is the amount of force moving the water.

Velocity is important to your design because of a condition called water hammer. Think about water flowing quickly through a pipe. If you were to quickly close a valve and shut off the flow, what would happen? It would be like you running face first into a brick wall.

The force that develops from such sudden halts of water flow is called water hammer. The force is a temporary increase in water pressure near the point of stoppage. If the velocity, speed, of the water is too great, the force of the water hammer can rupture the pipe, fittings, or valves.

Therefore, a safe range to keep the speed of the water moving through a sprinkler system is 5 feet per second. The range may vary slightly depending on the size, type, and strength of the pipe material.

Velocity is usually calculated by multiplying the flow rate in gallons per minute times a factor. The factor is based on the size and type of pipe. The multiplying factors are usually listed on the manufacturer's specifications for the pipe or the sprinkler component.

Now that you have covered the basics of design and hydraulics, try your hand at the subject review on the next few pages. After completing the review, continue reading the rest of this section.

Subject Review

Basics of Design and of Hydraulics

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. A good business practice is to design for the property owner the most ______ and ______ system and not just the least expensive system possible.	
2. PSI stands for ______ ______ ______ ______.	
3. One gallon of water weighs ______ pounds.	
4. The pressure of water when it is not moving is called ______ ______.	
5. One way to reduce the amount of pressure drop is to use a ______ size pipe for the supply line.	
6. The weight of a column of water 1 inch square and 1 foot high is ______ pounds.	
7. Calculating the ______ ______ for each circuit gives you some basis for setting the controller.	
8. The reason that many spray heads fog or mist is because of too much ______ at the head.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. When you design an irrigation system, you can consider the working pressure and the static pressure as the same.	
2. The installation of a system may not exactly match the design.	
3. Elevation has nothing to do with the working pressure in an irrigation system.	
4. Generally speaking, water is not compressible.	
5. Always leave a copy of the design with the property owner.	
6. One foot of head equals one psi.	
7. As a professional irrigator you recognize that throwing water on streets and sidewalks is unavoidable, and should therefore be of little concern to you or to the property owner.	
8. Always draw your designs such that only you know what they mean.	

Multiple Choice

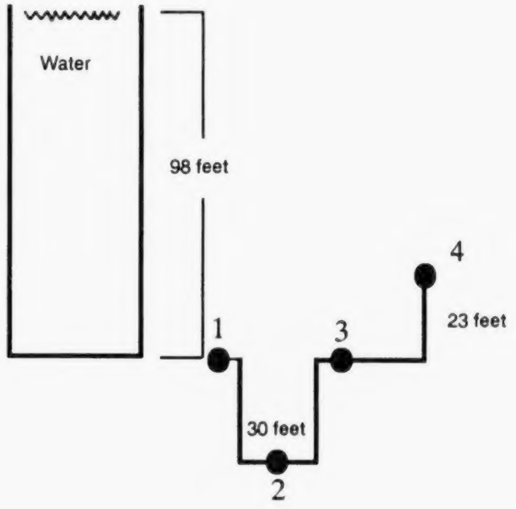
Indicate the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. If the water level in a water tower is 110 ft above ground level, the static pressure at ground level is A. 253 feet of head B. 110 feet of head C. 38.8 psi D. 63.6 psi E. 65.7 psi F. B and C	
2. Two gallons of water weighs A. .433 lbs B. 2.31 lbs C. 8.34 lbs D. 10.45 lbs E. 16.68 lbs F. 18.23 lbs	

Statement	Answer
3. Water pressure can be increased only by A. Using a larger water meter B. Using a smaller pipe size C. Raising the elevation of the water source D. Pumping the water E. Both A and B F. Both C and D	
4. The friction loss of water flowing through pipe is affected by A. The material the pipe is made of B. The size of the pipe C. The roughness of the inside surface of the pipe D. The I.D. of the pipe E. The flow rate and the velocity of the water F. All of the above	

Statement	Answer
5. Calculate the static pressure at points 1, 2, 3, and 4.	


Water
98 feet
1
2
3
4
30 feet
23 feet

1. ______C (98 ft x .433 psi/ft = 42.4 psi)
2. ______E (128 ft x .433 psi/ft = 55.4 psi)
3. ______C (98 ft x .433 psi/ft = 42.4 psi)
4. ______B (75 ft x .433 psi/ft = 32.5 psi)

(This page included for duplexing.)

Design Phase 1: Drawing A Plot Plan

Plot plan defined

In the irrigation business, a plot plan is a scale drawing of the property to be irrigated. A plot plan shows the dimensions of the property, the landscaping, and all structures, as well as indicates the presence of any items on the property such as utility poles. From a practical standpoint, the definition should also include the notes that you record about the property. As you will see, the notes can be as important as the measurements themselves.

A good way to produce a plot plan is to make a freehand sketch of the property. You need a pencil, drawing paper, compass, and a scaled ruler. You may also wish to have a T-square, triangle, protractor, French curves, calculator, and templates.

The drawing paper can be blank, but graph paper is much easier to use when drawing to scale. The ruler can be either in 8ths of an inch or 10ths of an inch. The choice is yours--but be consistent. Do not switch back and forth or you will very likely get confused and produce inaccurate drawings.

Determine the property boundary lines

Once you have your drawing materials, you need to determine the property boundary lines. This is usually fairly easy, but not always. Property lots may be irregularly shaped and structures such as fences may not follow the property lines. An architect's plot plan or a survey plot can help you determine the boundary lines. Homeowners sometimes have a copy of the architect's plot plan or the survey plot.

You want to determine the boundary line for a couple of reasons. First, you need to avoid putting any part of a customer's sprinkler system on someone else's property. Second, you want to throw as little water as possible on adjacent properties.

Measuring the property

A plot plan must be accurately drawn to scale. This means, of course, that you must accurately measure the property. "Stepping off" the distance is totally unacceptable. Even if you have an architect's plot plan, you should re-measure the property and double check the accuracy of the architect's plan. You may find that dimensions were changed from the architect's plan, or that items were added or deleted.

You will need an accurate measuring device. Two commonly used ones are a measuring tape and a measuring wheel. The measuring wheel is basically a counter attached to a wheel. The rotation of the wheel is shown as a distance on a display. Remember to keep your lines of measurement straight regardless of which measuring device you use.

Measure as accurately as you can. Generally, it is easier if you round off to the nearest half foot. Whether you round up or down is up to you, but be consistent. Decide on your rules for rounding and stick with them.

Be sure to take enough measurements to adequately design the system. It is better to have too many measurements than not enough. You will waste time and money if you have to return to a property to get additional measurements.

Indicating landscaping and other items

Your plot plan should also include the locations of landscaping items such as trees, bushes, shrub beds, flower beds, garden beds, and so forth. You should also include the locations of any items that may obstruct the water from a sprinkler systems. These include objects such as cooling/heating compressors, fire hydrants, mailboxes, utility poles, utility buildings, retaining walls, fences, and so forth.

Drawing an arc

Properties sometimes include arcs such as a curved street or a circle driveway. You need to draw such arcs as accurately as possible. Various methods exist for doing this. The method explained next is but one way.

Most curved curbs or circle driveways contain expansion joints. These are usually wood pieces placed into the curb or driveway at the point where the arc actually starts. Measure from a fixed point, such as the corner of a house, to each expansion joint.

Pick 2 points on the arc that divide the arc into thirds. For ease of discussion, we will call them Points A and B (you will have to estimate where the points are). From Point A, measure to 2 fixed points, such as the corner of a house and a corner of a sidewalk, etc.

On the plot plan, draw in the distances from the 2 fixed points. The place where the 2 lines cross is Point A.

Repeat the same procedure for Point B: measure to 2 fixed points and draw the distances on the plot plan. The place where the 2 lines cross is Point B.

You have now identified 4 points on the arc: the end points (the expansion joints), and Points A and B. Use a French curve and draw the arc from one expansion joint to the other. The arc must pass through Points A and B.

You now have an accurate drawing of the arc.

Plot plan notes

After you have drawn a plot plan that includes everything discussed so far, you next step is to take some written notes. Do not try to remember the information--write it down. Be as thorough as you can with the notes. You may sometimes need to take a photograph of a property as a further reminder. An instant picture camera works well for this (such as a Polaroid).

The following questions are included to help you with your note taking. Make sure that you answer each of the questions in your notes. If you do, your plot plan and notes will be invaluable when you design the system.

All of the questions are based on one rule: talk to the property owner. This is very important. You must find out what the property owner wants. The following questions help illustrate why.

1. Does the property owner plan to add items to the property or remove them?

For example, you need to know if the property owner plans to add a swimming pool, spa, utility shed, garden area, and so forth. Conversely, what if the owner plans to quit using a garden area (remove it) and cover it with turf? You need to know this type of information before you design the system.

2. Does the property owner object to water on any certain areas?

   For example, the owner may not want water thrown on the driveway, sidewalks, fence, or even the dwelling itself. (The water in some locations contains minerals that can stain brick, wood, and other building materials.)

3. Does the property owner have any special watering requirements?
   (This may also include areas of the property that the owner does not want irrigated.)

   You already know from previous discussions that different types of plants require different amounts of water. As a professional irrigator, you should be familiar with the watering requirements for the types of plants common to your locale. Even so, check with the property owner about special watering requirements.

4. Does the property owner want a manually operated system?

   If so, you need to find out if the owner wants the valves located in a specific place. The advantages and disadvantages of a manually operated system were discussed in Section 4. Some property owners want a manually operated system despite the disadvantages.

5. Where does the property owner prefer to have the controller located? Does the proposed location have electricity?

   Section 4 discussed controllers, where to locate them, and how to deal with the situation of no available electricity. You may wish to review that information at this time.

6. Does the property have sufficient hose bibbs?

Sometimes property owners would like to have additional hose bibbs around the property. Some residential customers prefer to have a hose bibb near the driveway to make washing their vehicles more convenient.

Also ask any other questions that may occur to you about the particular situation.

Observe the surroundings

Your plot plan notes should also include information based on your observations. The following items are reminders of the type of information to write down.

1. Note the direction of north in relation to the property.

2. Note any rises or falls in elevation.

   Changes in elevation, depending on the type of changes, can affect your design.

3. Note any underground utility boxes or lines.

   Utility companies will often post signs warning about the location of buried utility lines. As a general rule, contact the utility companies before you trench or dig.

4. Note the types of borders around the property.

   The borders may include curbs, gravel shoulders, drainage ditches, other properties, and so forth.

5. Note the direction of the prevailing winds.

Wind is the nemesis of sprinkler heads. You need to consider the direction of the prevailing winds when you plan your system. Dry spots can develop where you least expect them because of wind deflecting the water. You may need to add an extra head at a certain spot, for example, to allow for wind deflection.

Remember that the higher and the farther the water is thrown, the more susceptible it is to wind deflection.

Never depend on the wind to water an area for you. In other words, do not design a system such that it depends on wind-blown water to adequately cover the irrigated area.

6. Note if the property is using a water source other than city water.

If the property is using a water well, you need to determine the rating of the pump in gallons per minute and the size of the discharge pipe.

You may need to filter the water if it is from a source other than city water.

7. Note the items listed on page 79 in the ABC's.

Once you have an adequate plot plan, you are ready to enter phase 2 of layout and design.

(This page included for duplexing.)

Design Phase 2: Laying Out The Heads

Layout

After you have drawn an accurate plot plan, taken notes, and talked with the property owner, you are ready to layout the sprinkler heads. This involves deciding on which types of heads and patterns, the size of the patterns, and how to arrange the patterns.

Heads and patterns

Sprinkler heads and nozzles were discussed in Section 4 of your Guide and on pages 10 through 28 in the ABC's. Remember that spray, rotary, and hybrid type heads exist, as well as both circular and square patterns.

Once you decide on the type of heads to use, you can look at the patterns available within that type (full circle, part circle, large square, small square, etc.). After you determine the types of heads and patterns, you will need to space the heads correctly within the property.

Spacing patterns

The two types of spacing patterns are triangular and square. Since the ABC's explains them, this Guide will not discuss them in depth.

In triangular spacing, each row is offset from the row next to it (thus forming triangular patterns in relation to the heads). The distance between each head is the same. The distance between each row of heads, however, is about about 87% of the distance between each head. It is fairly easy to complete a triangulated design with a compass. The intersection of the compass arcs from any two heads is the point where you need a head.

Square pattern spacing is typically used in larger lawn areas. The distance between each head is the same as the distance between each row of heads.

Inconsistency in spacing

Unfortunately, not all property is square or rectangular. Sometimes you will have to adjust the head spacings based on the shape of the area being irrigated. Triangular and square spacing help to get you started. But arranging the spacings and patterns relies less on a scientific method and more on an artistic method. It is often learned by trial and error.

You want to ensure that the system fully covers the area being irrigated. This may require that you alter the spacing between heads, or add an additional head at certain locations. In other words, do not be afraid of inconsistency in your spacing if it ensures complete coverage.

With either triangular or square spacing, consistent or not, you must consider the overlap of the patterns.

Overlap

Overlap is usually expressed as a percentage of the diameter of the pattern. You may find it more convenient to discuss the size of patterns in terms of radius. Just remember that the diameter is twice the radius.

Opinions on the correct amount of overlap vary. For example, the ABC's mentions that the overlap of circular pattern spray heads should not exceed 80% of the diameter. For example, if a head throws a pattern with a 20' diameter, the spacing between heads would be 16' (80% of 20 is 16).

A more effective overlap, perhaps, is to stay in the range of 50% to 65% of the diameter. That is, never exceed 65%. In this range, the patterns should reach from head to head, or close to it.

Square pattern spray heads typically require less overlap than circular pattern spray heads. An overlap of 18" to 24" is usually sufficient.

Why have overlap?

The reason for a head-to-head overlap is that spray and rotary heads typically do not water close to the head itself. You have to throw water into the circular pattern to avoid dry spots. Dry spots are never acceptable in a design. Therefore, if you must change the spacing between heads, decrease it rather than increase it.

A well-designed sprinkler system with properly spaced circular pattern spray heads provides complete coverage because of the overlap. The same system, however, distributes water very unevenly. That may come as a suprise, but think about it. Some areas get watered from three different directions; they get triple watered. Other areas get double watered. And still other areas get watered only once.

Remember that complete coverage does not necessarily mean even distribution.

Where to begin a layout

There is no one specific way to layout the sprinkler heads. You may find it helpful to start with the corner areas. Determine the most effective and efficient way to irrigate the corner areas and work out from there. (You may place a head to throw out from a corner or into a corner depending on the circumstances.)

You can space the other heads based on the positions of the corner heads. A convenient step to do next is to place the heads in the areas that have special watering requirements. For example, the property owner may not want the fence, driveway, and sidewalks to get wet. Go ahead and place the heads such that these conditions are met.

Remember that shrubs and flower beds typically require less water than turf does. Rather than watering them along with the turf, a more efficient way is to use drip irrigation. Drip irrigation is discussed in Section 7. For now, just keep in mind that shrubs and flower beds can be watered other than from the turf heads.

Narrow strips of turf, such as parkways, are usually challenging to water. The ABC's, on page 88, discusses several of the methods used to water them.

After you layout the heads, you are ready to enter phase 3 of layout and design. Before you read about phase 3, however, complete the subject review on phases 1 and 2.

Subject Review

Layout and Design: Phases 1 and 2

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. The two most common methods of placing sprinkler heads are by ______ and ______ spacing.	
2. The two types of patterns from spray heads are ______ and ______.	
3. The ______ pattern requires the least amount of overlap.	
4. It is almost always better to ______ the spacing between heads to achieve a better fit than to ______ the spacing.	
5. ______ paper is usually helpful in designing a sprinkler system.	
6. With true triangular head placement, the distance between rows is ______ percent of the spacing between the heads.	

Statement	Answer
7. Always check the water pressure at a location with a ______.	
8. ______ strips of turf are challenging to water efficiently and effectively.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. You should always verify the dimensions of property with an accurate measuring tool.	
2. With triangular head placement, the spacing from head to head and from row to row is the same.	
3. On plot plans, you should include the locations of shrub and flower beds only because they may create an obstruction.	
4. On plot plans, you should always include the locations of trees, utility poles, and any other structures such as a storage building.	
5. Overlap circular pattern sprinklers as little as possible.	
6. Always irrigate any lawn areas with as few heads as possible to achieve full coverage.	
7. It is always preferable to water shrubs, flowers, and lawn at the same time if possible.	
8. For certain slopes, you may have to use sprinklers with a low precipitation rate.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Some of the items that you must know to design an efficient sprinkler system include A. Desires of the property owner B. Size and location of the city water meter C. Size, shape, and location of flower beds D. Location of trees and utility poles E. A and B only F. A, B, C, and D	
2. Sprinkler head spacing should be based on A. Types of heads and sizes of patterns B. Slope of property and location of trees C. Water pressure D. Both A and B E. Both A and C F. A, B, and C	

Statement	Answer
3. When you need to find out the size of a property, it is sufficient to A. Use the measurements from an architect's plan of the property B. "Step off" the distance, which will measure close enough for irrigation systems C. Use a measuring tape to measure D. Use a wheel-type measuring device to measure E. Both A and B F. Both C and D	
4. A few dry spots in a design are A. Acceptable if the spots are at the bottom of an incline where run-off water will reach them B. Acceptable because wind and run-off will usually get water to the spots C. Acceptable if the design has no more than three such spots D. Acceptable if the design has no more than three such spots and at least two of the three appear side by side E. Both A and B F. Never acceptable	

Statement	Answer
5. A well-designed sprinkler system with properly spaced circular pattern spray heads A. Distributes water very evenly B. Distributes water very evenly unless the ground is hilly C. Distributes water very evenly if the correct wind loss factor has been figured into the design D. Distributes water very unevenly E. Distributes water very unevenly unless a filter keeps the water clean F. Distributes water very unevenly only if the water is blocked by obstructions such as trees	
6. An effective spacing for circular pattern spray heads is A. 10-20 percent of the diameter of the spray pattern B. 30-40 percent of the diameter of the spray pattern C. 40-50 percent of the diameter of the spray pattern D. 50-60 percent of the diameter of the spray pattern E. 65-85 percent of the diameter of the spray pattern F. None of the above	

Statement	Answer
7. The spacing of sprinkler heads A. Can be done scientifically if you use Davidson's Placement Formula B. Can be done scientifically if you use the Bourge scaling method C. Relies less on a scientific method and more on an artistic method D. Is often learned by trial and error E. Both A and B F. Both C and D	
8. Overlapping the patterns of circular spray heads A. Is necessary to avoid dry spots between patterns B. Is necessary because water pressure will always decrease in the summer season C. Is necessary because most lawns are rectangular and the only way to reach the corners is by overlapping D. Both A and B E. Both B and C F. None of the above	

(This page included for duplexing.)

Design Phase 3: Sectioning The Heads
(adding the plumbing)

Sectioning as a series of steps

Pages 99 through 106 in the ABC's discuss dividing the heads into groups (called sectioning). The information may seem intimidating at first. But sectioning the heads is really just a series of steps within itself. If you follow the steps one at a time, the whole process is easier to understand.

For example, the following list summarizes the main points from pages 99 through 106, and also includes supplementary information. The list is to help you get an overview of the steps involved in sectioning the heads.

The list is not a substitute for thoroughly understanding the information on the pages.

1. Determine the static pressure and the size and flow rate of the water meter. Apply the 75% rule to the supply volume.

The rating in gallons per minute is imprinted on some types of meters. Check the meter to see. If not, you can find out the rating from the meter manufacturer or from various tables that list how much water can pass through a given size meter at a given pressure.

Always test the flow rate of the water. At least turn on a hose bibb and see if you get a trickle or a full stream or water. Do not base your design strictly on static pressure because conditions may exist of which you are not aware. For example, suppose that the supply line from the water main to the meter has a crimp in it. Your static pressure will still read the same. But, instead of getting 16 gallons per minute through the meter, you may get only 6.

2. List the types of sprinklers that you are using, their discharge rates, and their minimum and maximum operating pressures.

3. Divide the sprinklers into sections, starting at the source of the water supply.

   A good practice, if you have triangular placement of the heads, is to section the heads by rows. This also often adds to the consistency in the overall aesthetic appeal of the system and usually reduces the amount of pipe required.

   The amount of water available at a given time determines how many heads that you can put in a given section. The amount of water used by all of the heads in a section must be less than the total amount of water available. Otherwise, you have too many heads in the section.

4. Estimate where the main supply line will run (you can change it later if necessary).

5. Calculate the friction loss for the farthest section and for the largest section by using the "quick check" method.

   You will need to refer to pressure loss tables such as those in the back of the ABC's.

   Pressure loss charts are usually calibrated in psi per 100 feet. Remember to divide the pressure loss number from the chart by 100, then multiply that answer by the number of feet.

   Apply the 90% rule to the static pressure.

   If either the farthest or the largest circuit requires a pressure greater than the design static pressure, resection the heads and repeat this step.

6. Add the piping (after you have successfully sectioned the heads).

   Do not size the pipe yet.

7. Add the valves.

   A reasonable practice is to put the remote control valve somewhere close to the middle of its circuit. This gives you have a consistent pressure drop from the center to either end. In all cases, you cannot locate it near the center. One reason, of course, is that the locations of the valves determine where the supply line will run.

8. Route the main supply line.

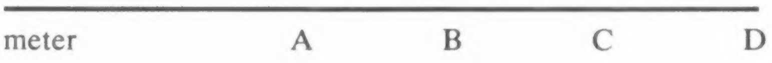
   For some installations, looping the supply line around the property and back to itself can be advantageous. Looping the line gives the effect of having 2 supply lines to each section--1 line from each direction. You may be able to reduce the size of the supply line 1 size as well as reduce the total amount of pressure loss.

   Sometimes the looping requires only a small amount of extra pipe (an extra 20 feet of pipe to go underneath a driveway, perhaps). Keep in mind the economic and design benefits of looping the supply line. If it improves the installation, use it.

9. Size the pipe and valves.

   When sizing pipe, use the smallest pipe that can safely carry the amount of water that has to pass through it. How much water has to pass through a section of pipe? Let us look at an example.

Suppose that you have the following arrangement of pipe and sprinkler heads. Each head discharges 4 gallons per minute.



Pipe Section From	Carries The Water For	Section Must Carry
meter to head A	Heads A, B, C, and D	16 gpm
head A to head B	Heads B, C, and D	12 gpm
head B to head C	Heads C and D	8 gpm
head C to head D	Head D	4 gpm

Decreasing the pipe size causes the water velocity to increase (there are hydraulic limits to this rule, of course).

Remember to keep the velocity about 5 feet per second. You must also check the pressure drop for each section of pipe to make sure that you have enough pressure to operate the head. (The discussion about Design Phase 4 explains that more fully.)

Fortunately, some pressure loss charts list all this information: the pressure loss factors, and the velocity (feet/second) of a given rate (gpm) through a given size pipe.

Now that you have an overview of sectioning, reread pages 99 through 106 in the ABC's until you have a thorough understanding of the information. Pay close attention to the drawings and the mathematics that accompany them.

After you feel comfortable with the information, return to this Guide and read about Design Phase 4.

Design Phase 4: Check Your Design Mathematically

After you complete a design, you need to check it mathematically. This check ensures that all of your calculations are correct and that the system will function as designed.

Pages 107 and 108 in the ABC's discuss the final check. Reread those pages until you are thoroughly familiar with the information.

Notice that you calculate the minimum required operating pressure for the circuit farthest from the meter and for the largest circuit. If those two circuit will operate, you can usually assume that all other circuits will operate. But check each circuit if you have any doubt about whether or not it will operate.

Follow the bouncing bubble

Imagine that you are going to follow a bubble from the water meter to the farthest head in a system. You will need to keep track of everything along the route that causes the water pressure to drop. Do not include any lines that branch off from the route because that bubble does not branch off--it bounces along directly to the head.

The following list summarizes what to keep track of:

The water meter itself
Any backflow prevention devices
Any valves
The total length of the pipe
Any change in elevation of 10 feet or more
Any component in the system that causes turbulence in the water
The minimum required pressure for the head

Pressure loss also occurs through certain types of fittings. For practical purposes, the loss is typically very small and usually can be ignored. If you have a very large system that is operating very close to the maximum, you may need to include the fittings. But usually the accumulative affect of all of the fittings is negligible.

Add all of the pressure loss numbers together. The result, plus the minimum head operating pressure, is the minimum pressure required to operate the farthest circuit.

This number must be less than your design static pressure. (Remember, design static pressure is 90% of the static pressure.) If the number is larger, you need to adjust your design and recalculate.

After calculating the pressure loss for the farthest circuit, repeat the process for the largest circuit.

The mathematics involved for the final check is not difficult, but you do need to be careful during the process. Make sure that you have included a pressure loss for everything in the system that causes pressure loss. Verify that you are using the correct table or chart before using a pressure loss number from it.

Subject Review

Layout and Design: Phases 3 and 4

Fill In The Blank

Supply the word or words in the answer column to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. When you size pipe, make sure that the size is not too ______.	
2. When you use PVC pipe, a safe critical velocity for the water is ______.	
3. Water flowing from a sprinkler nozzle may travel a greater distance than it would from an open ended water hose because the nozzle increases the ______ of the water.	
4. Any reduction in the size of pipe through which water flows, or any abrupt change in the direction of the flow, causes a ______ in the water ______.	
5. A reasonable way to check if a sprinkler system will work correctly is to calculate the pressure drop (loss) in the ______ circuit and in the ______ circuit.	

Statement	Answer
6. Choose the size of pipe and the placement of the valves so that you reduce the total ______ of pipe needed and reduce the pressure ______.	
7. Place manual control valves so that the operator does not get ______ when turning the valves on or off.	
8. Pressure losses are cumulative only in a direct ______ from the farthest point to the water source.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Pipe in a sprinkler system is sized to maintain velocity.	
2. Pipe in a sprinkler system is sized efficiently to save the buyer money.	
3. When you want to estimate how much water is available for a sprinkler circuit, all you need to know is the static pressure, meter size, and service line size (main to meter).	
4. Friction loss tables are usually listed in PSI per 100 feet.	
5. Heads with greatly different precipitation rates should never be operated on the same circuit.	
6. All plants require roughly the same amount of water, and can be watered at the same time and with the same amount of water.	
7. Plant types and requirements are of no interest to the professional irrigator.	
8. The actual operating pressure at a head does not matter as long as it is more than the minimum operating pressure needed for the head.	

Multiple Choice

Circle the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer

1. Pipe is progressively sized down in a a sprinkler system

   A. To maintain water pressure
   B. To maintain water velocity
   C. Because small pipe costs less than large pipe
   D. Because the number of circuits keeps increasing
   E. Both A and B
   F. None of the above

2. Looping a main supply line in a sprinkler system can

   A. Lower the pressure loss to the circuits
   B. Allow you to use smaller pipe for the main supply line
   C. Increase the water pressure to the system
   D. Allow you to adjust the heads easier because of better water pressure
   E. Both A and B
   F. Both C and D

Statement	Answer

3. Water hammer

   A. Can be removed if you size the pipe correctly
   B. Can be removed if you use a larger water meter
   C. Is only a problem with PVC pipe
   D. Should be kept at a safe level
   E. Both A and B
   F. None of the above

4. For all practical purposes, static pressure

   A. Is the same throughout a piping system
   B. Is the same throughout a piping system if the water is flowing
   C. Is the same throughout a piping system if the water is not flowing
   D. Differs at each valve in a sprinkler system
   E. Is lower in small diameter pipe than in large diameter pipe
   F. Is greater in long sections of pipe than in short sections of pipe

5. The number of heads in a single section depends on

   A. The total gallons of water available
   B. The total gallons of water required by the heads
   C. The size of the pipe
   D. The number of valves
   E. Both A and B
   F. Both C and D

Statement	Answer
6. Generally, the total pressure loss through a circuit plus the minimum operating pressure of the sprinkler heads in the circuit should be no more than A. 50% of the static pressure B. 60% of the static pressure C. 70% of the static pressure D. 80% of the static pressure E. 90% of the static pressure F. None of the above	
7. The fittings in a system A. Do not cause any pressure loss B. Cause such a small amount of pressure loss that usually you can ignore it C. Cause a great deal of pressure loss D. Cause a pressure loss only if the fittings are thermoplastic E. Cause a pressure loss only if they reduce the size of the orifice through which the water passes F. None of the above	

Statement	Answer
8. You have a section of 3/4" PVC pipe 72' long. On a chart, you find the friction loss factor is 2.87 psi / 100' at a water velocity of 5 ft/sec. The friction loss through that section of pipe is. A. 206.6 psi B. 25.08 psi C. 2.06 psi D. 1.89 psi E. 0.92 psi F. None of the above	

(This page included for duplexing.)

Section overview

In the appendix of your Guide is a publication from the Texas Water Development Board titled "Drip Irrigation." If you have not already read it, please read it before continuing in this section.

This section discusses drip irrigation, how it originated and why it works successfully. In addition, this section offers the professional irrigator much information about the watering requirements of plants. In fact, even before getting to drip irrigation, you need to know something about the relationship of water, soils, and plants.

When water meets the soil

Soil is typically in layers that range from greater compaction to lighter compaction. The layers may or may not be well defined, but to some extent the layers exist in all soils.

Water penetrates the soil one layer at a time. Another term for penetration is percolation. The leading edge of the water as it moves down is called the wetting front. Each layer fills up until it reaches a point that is called its field capacity. The field capacity is how much water the layer will hold before the water continues to move on down.

Field capacity is not necessarily the same thing as saturation point. Saturation occurs when the soil is incapable of holding any more water.

Speed of percolation

The speed at which water can move through soil depends directly on the size of the particles in the soil. Small particles are usually referred to as "fine"; large particles are referred to as "coarse."

As a general rule, the finer the particles, the slower that water moves through the soil. Clay soils, for example, have the finest particle size of all. This is the reason clay soils get gummy and thick when wet. Water moves slowly through clay soils.

Sandy soils, on the other hand, have coarse particles. Water moves quickly through sandy soils.

It is important for you to know how deeply into the soil water penetrates and how rapidly.

One of nature's cycles: evapotranspiration

What happens to the water when you irrigate? Some of it reaches the plant roots and some of it does not. The water that reaches the roots is absorbed and passes up through the plant. The water carries nutrients throughout the plant. Eventually, the water travels out to the leaves of the plant and is discharged as vapor. This process of absorbing and losing water is called transpiration.

Evaporation also claims a portion of the water applied. Some of the water evaporates from the soil before it ever reaches the plant roots.

These two processes, transpiration and evaporation, are called evapotranspiration. Together, they make up the actual water requirement of a particular plant.

Ideally, you want to maintain a moisture level in the soil at the point where the water is replenished at exactly the same rate as the plants use it and as it evaporates.

Plants require oxygen to live, which they take in through their roots. If you saturate the soil, you wall out all of the oxygen. Plants cannot take in oxygen from the water. So, in effect, they suffocate from lack of oxygen.

Incidentally, many plants appear the same when suffering from over watering as from under watering. They begin to wilt and turn yellow. Many people assume that yellowing leaves indicates lack of water, so they water the plant more. The plant, however, may be drowning, not suffering from thirst. Do not assume: always check the moisture level of soil with a moisture meter. More about that later.

ET rates

Evapotranspiration is often abbreviated as ET, and is usually referred to in terms of rate. The rate is commonly measured in inches of water per day. The ET rate tells you how many inches of waters per day needs to be replenished for a certain type of plant.

Calculating ET rates is a detailed process because so many things affect the rate. Almost everything that the plant is exposed to has an influence: the temperature, cloud cover, wind, humidity, mulching, the number of plants, and so forth.

You can usually get a list of ET rates from your local county extension agent. Product literature for certain brands of irrigation equipment sometimes lists ET rates also.

Some charts of ET rates list what is called a potential evapotranspiration rate, or PET. A PET is like an average for a particular time of year, usually mid summer, and for different climates.

How much water does a plant need?

What you want to do as an irrigator is to tell a customer about how much water a plant can be expected to use. A formula exists to help you:

$$\frac{.623 \times \text{canopy size} \times \text{PET} \times \text{plant factor}}{\text{Irrigation efficiency}} = \text{Gallons per day for plant}$$

Where:

.623 = Conversion factor to convert inches of water per square foot of area to gallons. It takes .623 gallons of water to cover a square foot to a depth of one inch.

canopy size = Plant area in square feet (the area under the canopy of the tree, for instance). If you draw a circle around the drip line on the ground, the area of that circle is the canopy size. Remember the formula for figuring the area of a circle: Square the diameter of the circle and then multiply by 0.7854.

PET = Potential evapotranspiration rate.

plant factor = A number that varies with the type of plant. Plant factor numbers are sometimes available from nurseries or in product literature for certain brands of irrigation equipment.

Irrigation efficiency = The efficiency of the irrigation in applying the water. Irrigation is never 100% efficient; some loss always occurs. You strive to keep that loss to a minimum, but you always have some. Drip irrigation is very efficient: 85% in hot, dry climates; 90% in moderately hot climates; and 95% in cool or humid climates. Sprinkler irrigation efficiency is normally less, and depends on sprinkler type, climate, wind, etc.

The formula gives you the gallons of water per day that need to be applied to a particular plant to replenish the water used through evapotranspiration.

For example, a shrub with a 3 foot diameter would require 1.22 gallons per day in a moderate climate if you used drip irrigation:

$$\frac{.623 \times ((3 \times 3) \times .7854) \times .25 \times 1.0}{.90} = 1.22 \text{ gpd}$$

Root depth and irrigation

Plants need to grow their roots to a depth that most benefits the plant. For turf grasses, the depth is about 6 inches in clay soils, and deeper in sandy soils, down to about 12 inches in some cases. Watering should encourage proper root growth--which brings us right back to proper irrigation.

Let us look at clay soils as an example. If you water in only very small amounts, the water penetrates the soil only to a very shallow level. If you do this over a long period, you encourage the plant roots to become shallow. The roots grow to where the water is.

Do not assume that the water just keeps running down through the soil. It does not. In fact, if applied in very small quantities, the water may soak into just the top inch or so. It remains there until either the plants absorb it or it evaporates.

What you want to do is apply enough water to soak down to the bottom of the root zone, but no deeper. Water that goes below the root zone is basically wasted because the plants make no use of it.

1 inch per week

As it turns out, applying one inch of water per week to clay soils typically gives about 5 to 6 inches of penetration. It gives about 8 inches of penetration in a loam, and about 12 inches of penetration in sand. This is why you hear that number, 1 inch per week, so often in the irrigation business.

Obviously, depending on the type of soil, you cannot apply the water too rapidly. The finer the soil particles, the less rapidly the soil absorbs water. Try to apply too much too quickly and you cause runoff.

All this points to an efficient way to water--a slow, frequent application of water over a long period. And that is what drip irrigation is all about. That is why drip irrigation is embraced by one of the 7 Xeriscape principles.

Xeriscape

Xeriscape means conserving water through creative landscaping. Or, said another way, water-efficient landscaping. The term was coined during a water conservation project in Denver, Colorado in 1978.

Xeriscape incorporates 7 principles that lead to saving water:

1. Planning and design of the landscape

   Creating a well-thought-out landscape design is where saving water begins. Plan a landscape instead of adding one haphazardly.

2. Limited turf areas

   Limiting the amount of turf area is a very effective way to save water. Turf grasses almost always require more water than other landscaping plants.

3. Thorough soil preparation

   Adding organic matter to soil helps to increase plant health and conserve water.

4. Efficient and effective irrigation

   The goal of any irrigation system is to supply plants with enough water without waste. Drip irrigation is ideally suited for this.

5. Mulching

   The benefits of mulching are discussed later in this section.

6. Adapted, lower water-demand plants

   Select trees, shrubs, and ground covers based on their adaptability to your region's soil and climate.

7. Proper landscape maintenance

   Maintaining a landscape, such a mowing grass to the proper height, also helps conserve water.

As a professional irrigator, you should also support water conservation. The principles of Xeriscape are excellent practices to follow and promote.

If you are interested in learning more about Xeriscape, check with your local Extension agent. In addition, you may want to become a member of the National Xeriscape Council (which, incidentally, is headquartered in Texas). Their address is:

National Xeriscape Council, Inc.
940 E. Fifty-first St.
Austin, Texas 78751-2241

The roots of drip

Drip irrigation came into being during the late 1960's and has become prevalent only in the last several years. Historically, drip irrigation had its greatest development in the Middle East, particularly in Israel. A number of Israeli drip irrigation manufacturers sell products in the United States.

Climatically, the Middle East has some very harsh areas in which to grow crops. Drip irrigation allows crop growth in such arid regions.

Fill 'er up: car

Is it possible to water just as efficiently with a sprinkler system as with a drip system? No. Let us look at an analogy between gasoline in your car and water in soil to explain this.

Suppose that the tank on your car held only 6 gallons and that you could drive for 1 week on that amount. You put in 6 gallons, drive your car until the tank is almost empty, then put in about 6 more gallons. You have to stop every week to put in 6 gallons.

You could refill the tank when it is only half empty--after half a week--but you would still have to stop. Imagine how convenient it would be if your tank were refilled at the same rate that you burned the gasoline. You would always have 6 gallons of gasoline and would never have to stop for more.

Fill 'er up: soil

Now consider a situation where the bottom root zone of a plant is 6 inches down. Starting with completely dry soil, you need to "fill'er up" to get the water down 6 inches. Assume that you accomplish this by running a sprinkler system for 1 hour to apply 1 inch. That amount of water soaks down 6 inches, which is exactly what you want. Apply more than that and you just waste water.

Assume further that the soil will dry out completely again in 1 week. Now what do you do? You could wait 1 week, let the soil dry out completely, and then apply another 1 inch of water. (That, by the way, is what turf grass authorities suggest for turf--soak it deeply, let it dry out almost to the point of wilting, then soak it again.)

Or, you could wait half a week and apply 1/2 inch of water. But 1/2 inch of water soaks down only 3 inches, not 6 inches. And you want the roots to stay 6 inches deep, not come up to 3 inches looking for water.

Imagine how convenient it would be for the plant if the water in the soil was replaced at the same rate as it was lost. Drip irrigation can accomplish this. Sprinklers cannot. As we just pointed out about sprinklers, watering 1/2 inch every half week does not produce the same results as watering 1 inch every week.

(Incidentally, the feeder roots of most plants, even shrubs and trees, are in the top six inches of soil. This is one reason why you want to remove grass from beneath trees--it competes for the water.)

Stable soil moisture

Drip irrigation can maintain a stable content of soil moisture. This causes much less stress on plants than a "feast or famine" way of watering. You can keep plants in a situation of always having water available. They never have too much or too little. Drip irrigation applies water under low pressure, at low flow rates, at frequent intervals, and usually at specific points (directly at the plant).

Drip irrigation is practical for fairly long distances because it operates at low pressures--usually between 10 and 40 psi. Because the water moves very slowly, it produces very little pressure loss. This allows you to distribute water to plants scattered over a large area and still have enough pressure to operate. That operating pressure is the pressure required to operated an emitter.

Emitters

The outlet which dispenses water from a drip line to the plants is called an emitter. Strictly speaking, a hole in a drip line is an emitter, although emitters are usually thought of as devices. Several types of device emitters are available. The Drip Irrigation publication in your Guide shows 2 types.

Some emitters compensate for differences in pressure to achieve a given flow. This type is useful if you have vast changes in elevation to allow for. Other types of emitters are rated to disperse a given amount of water over a certain period of time. Most emitters, and irrigation products in general, are rated in gallons per hour instead of gallons per minute. Still other types of emitters have multiple outlets.

Any emitter creates a flow restriction, which causes a pressure drop at that particular point. The pressure drop is created by one of two methods. One method, of course, is the hole itself--a very tiny orifice through which the water escapes. The other method is by channeling the water through a tortuous path or maze. The more complicated the maze, the greater the pressure drop. This is how emitters can be constructed to deliver a certain amount of water within a certain amount of time.

Supply lines and laterals

Like emitters, the other components of drip irrigation systems are basically very simple. A drip system needs a supply line just as does a sprinkler system. Supply lines are usually made of flexible, 1/2 inch polyethylene pipe. They are usually connected with a quick-connect fitting such as a press-lock or barbed type.

From the supply line, you build a pipe line, or lateral line, to each particular plant. The lateral lines can be tubing, such as double-walled, or very small, flexible polyethylene tubing, sometimes called micro tubing.

Double-walled tubing has a small tube attached piggyback to a bigger tube. The Drip Irrigation publication in your Guide illustrates this type. Notice that the bigger tube must fill with water before the smaller tube can. This helps equalize the pressure and distributes the water more evenly. The holes in double-walled tubing are often cut by a laser.

Spacing intervals

Space the emitters or double-walled tubing at fairly frequent intervals. The spacings of the plants will often dictate the spacings of the emitters. For double-walled tubing, the distance between laterals depends on the type of soil. The finer the soil, the broader the wetting pattern is going to be. You can space the intervals further apart in clay soil than you can in sandy soil. Double-walled tubing is generally spaced 12 to 18 inches.

Above or below ground

The double-walled tubing and micro tubing can be placed above or below ground. Burying them below mulch is particularly effective. (Incidentally, mulch offers a variety of benefits: it insulates the soil, moderates the soil temperature, reduces evaporation, reduces erosion, and helps reduce the amount of weeds. Encourage property owners to use it where applicable.)

Using the tubing above ground has several advantages. The tubing can be easily moved. For instance, you could pull it off a garden when you needed to till and plant, then replace it. Most drip products are polyethylene and relatively immune to freeze damage. Most of the products also drain naturally (walled tubing tends to flatten and squeeze out the water).

If you bury the tubing, keep it between 3 and 6 inches deep. Be careful not to go below the root zone of the plants being irrigated. Also remember that the pear-shaped wetting profile expands out to the sides. It gets fatter as the water gets deeper. As you bury the drip strip, you are also lowering the level at which you get the fattest point of that wetting pattern.

Pressure regulators

A pressure regulating device is often a necessary component of a drip system. The 2 types are fixed and adjustable. Fixed regulators limit the output pressure to a preset rate (usually about 15 psi). The output pressure can vary, however, if the input pressure is too great (usually above 70 psi). Adjustable regulators allow you to set the output pressure within a specified range.

Injectors

Another useful component in drip systems are chemical and fertilizer injectors. A variety are on the market and are commonly used in agricultural applications. They allow you to apply pesticides or fertilizers through the drip system.

A fertilizer injector is very useful for adding chlorine to a drip system. A major cause of emitter plugging in double-walled tubing is bacteria growing around the openings, around the orifices. Chlorine will eliminate the bacteria. If you use chlorine tablets, make certain that they dissolve completely into very small particles. Otherwise, you may clog the emitters with pieces of tablet.

Compatibility with existing systems

Drip irrigation is very compatible with sprinkler systems. The drip system can be on one circuit, controlled by the controller just as the other circuits. The main problem is whether or not the controller allows sufficient watering time per cycle. Drip irrigation requires fairly long watering times, particularly during the summer.

You can use the same type of solenoid valve that you use for the rest of your sprinkler system. Most manufacturers have connectors that allow you to connect the drip tubing to PVC or polyethylene.

Advantages and disadvantages of drip

The Drip Irrigation publication in your Guide lists the major advantages and disadvantages of drip irrigation. Notice that the advantages outnumber the disadvantages.

Drip irrigation systems are fairly quick and easy to put together. The products themselves typically have a very low cost per component. But you must have a product for every plant. If you have a lot of plants, you can need a lot of products, and that can run into a high cost.

On the other hand, drip irrigation products are perfect for the do-it-yourself person because they are so easy to put together. Be aware that drip equipment from different manufacturers may not be compatible. Generally, it is advisable to use the same brand of product throughout a drip system.

As a general rule, you cannot use drip irrigation to water turf. It is impractical from a maintenance standpoint and often from an installation standpoint.

As the "Drip Irrigation" publication points outs, salt buildup may be a problem with drip irrigation is some locations. The salts in the water and soil tend to precipitate at the edges of moist areas. If you anticipate problems with salt accumulation, locate emitters so that the wetting patterns overlap.

Coring tool and moisture sensor

Two pieces of equipment that you should be familiar with as a professional irrigator are a coring tool and a moisture sensor. They are not actually part of a drip system, but they are useful when determining the efficiency of a drip system.

A coring tool allows you to take a plug sample of soil and plant material and visually determine root depths. A moisture sensor indicates the relative wetness of soil. You can check the moisture at various depths depending on how deeply you insert the sensor probe.

Both a coring tool and a moisture sensor make it easier to determine the moisture content at a given depth.

Practice makes perfect

Now that you have learned about drip irrigation, complete the subject review on the next few pages. Also note that Laboratory Exercise 3 is on drip irrigation.

(This page including for duplexing.)

Subject Review

Drip Irrigation

Fill In The Blank

Supply the word or words to complete the following statements.

Then, after the questions are discussed in class, place an "X" through each incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Drip irrigation, properly operated, allows for very successful plant growth because plants have less ______ because of variations in soil ______.	
2. It is generally not possible to achieve the same growing efficiency with sprinklers as with drip irrigation because sprinklers apply water much too ______.	
3. Drip irrigation allows the ability to accurately adjust ______ rates to individual plant ______.	
4. When using drip irrigation in some areas, it is necessary to be aware of possible ______ build-up around the wetting pattern of an emitter.	
5. Drip emitters restrict and control water flow by means of a small ______ or by a water channel that takes a ______ path.	

Statement	Answer
6. Water containing any solid particles requires the use of a ______ on a drip system.	
7. Emitter plugging is frequently caused by the growth of ______ in the orifice.	
8. In drip tubing, such as double-walled, the small laser-drilled orifices serve the same function as ______.	

True or False

In the answer column, mark the following statements "T" for true or "F" for false. The whole statement is false if any part of it is false.

Then, after the questions are discussed in class, place an "X" through an incorrect answer and write the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Modern drip systems are usually very dependable if designed, installed and operated properly.	
2. The penetration of soil by water as it saturates the soil and moves downward is referred to as percolation.	
3. Water penetration is fastest through fine soils, like clay.	
4. Water retention is greatest in coarse, sandy soils.	
5. Evapotranspiration rates depend, to some degree, on whether or not mulch is used.	
6. Drip irrigation allows for better growth with less water use than conventional methods.	
7. Mulches should only be used around shrubs and trees, and never around flowers.	
8. Tree growth is unaffected by grass growing beneath it.	

Multiple Choice

Indicate the letter of the choice that best completes the statement.

Then, after the questions are discussed in class, write the letter of the correct answer in the answer column. That way, you will know the correct answers if you later review this information.

Statement	Answer
1. Drip irrigation is characterized by which features: A. Low flow rate and low pressure B. Long watering periods C. Frequent watering intervals D. Selective areas of application E. Only A and B F. A, B, C, and D	
2. Drip irrigation is very suitable to water plants that are spread out over a large area because A. It is very inexpensive B. It requires no maintenance C. It uses low flow rates and has low pressure losses D. A and B E. B and C F. None of the above	

Statement	Answer
3. Water penetrates faster through A. Course, sandy soil B. Fine-textured soils like clay C. The wetting front D. The root zones of plants E. Soil covered by tree foliage F. None of the above	
4. The water requirement of a given plant in a given climatic condition in a given planting situation can be defined as A. Wetting front B. Evapotranspiration C. Precipitation rate D. Field capacity E. .623 X gallons per day F. Root zone reservoir capacity	
5. Drip irrigation is impractical for use in A. Orange groves B. Pecan groves C. Ground cover D. Chinese tomatoes E. Turf F. Hothouses	

Statement	Answer
6. The daily water requirement in gallons for a given plant can be determined by: A. Bernoulli's equation B. (Irrigation + rain) - evaporation C. .623 X canopy area X potential evapotranspiration X plant factor / irrigation efficiency factor D. Potential evapotranspiration rate E. Potential evapotranspiration rate - evaporation / (irrigation efficiency factor + canopy type) F. None of the above	
7. The basic reason why drip irrigation is very successful for watering plants is that A. It is very inexpensive B. It is suitable for use with dirty water C. It allows chemical injection pumps to be used for fertilizer distribution D. Soil moisture content can be kept at a relatively constant and proper level E. It reduces weed growth F. Both A and B	

Statement	Answer
8. The reasons why drip irrigation is considered very water efficient are A. Precise water placement and control B. Less water lost to wind and evaporation and reduced weed growth C. Saturation is avoided because water is applied slowly D. Energy savings because of lower power requirements E. Both A and B F. A, B, C, and D	

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8. Irrigation Considerations

Section overview

This section discusses subjects with which a professional irrigator needs to be familiar. The subjects include codes and ordinances, landscape design and irrigation, beautification, and the efficiency of water use.

Codes and Ordinances

Most cities in Texas have structured codes governing plumbing, particularly the way in which cross connections may be made to the potable water supply. The rules and regulations are usually very specific, and frequently cover such areas as the types of backflow prevention devices that are acceptable and the burial depth of service lines.

Irrigation is relatively new in terms of being controlled by laws. Because of this, irrigation in many cities falls under the code administration of the plumbing group.

Often, however, plumbing codes have little relation to modern technology. The codes have a tendency to be a decade or more behind. This is somewhat normal: technology changes much more rapidly than the legislative processes to create and change laws. Technology evolves and challenges the laws to catch up.

Municipal utility districts, often referred to as "MUDs", have rules governing plumbing and irrigation that are frequently outdated. So codes and ordinances become restrictions that may or may not be realistic. Remember that the underlying reason for most of the codes, however, is to deter the irrigator from doing something irresponsible.

Most cities that have laws also have employees whose job it is to determine whether or not these laws are being complied with. In the case of irrigation systems, this person is the code inspector.

The code inspector ensures that the irrigator and the consumer comply with city codes, even if those codes are outdated. The code inspector does not interpret the code, but rather enforces those interpretations which have been made.

The situation is similar to that of a judge and a police officer. A judge interprets the meanings of law and makes some judgment on right and wrong. The police officer does not create laws nor interpret them, but rather enforces the law against the masses. That is exactly what enforcement of codes and ordinances is about.

The code inspector is not your enemy. At times, that may be difficult to accept. Bureaucracies, and their representatives, sometimes exhibit an attitude of confrontation instead of cooperation.

It is your responsibility to understand and comply with the codes and ordinances of your community. If the codes are outdated, then you need to use the slow, but always successful, process of educating your community about the new technologies. Visit with your plumbing commission and your plumbing code group. Visit with your city council. Talk with the people involved: do it in the sense of professionalism rather than just violating the law and going about your business.

Get the codes and ordinances revised. Demonstrate your willingness to comply with the law, but also show your determination to require laws as current as possible.

Landscape design and irrigation

All of the plants in a landscape have to be watered. That is where we, as irrigators, come in. Irrigation serves the landscape.

Interestingly, professional irrigators and professional landscapers seldom, if ever, design a landscape together. More often than not, the irrigator is concerned that the landscaper has laid out designs that are difficult, if not impossible, to irrigate, and for no better reason than the landscaper has no understanding of irrigation technology.

The landscaper, on the other hand, is often upset at the irrigator for tearing up the landscape while installing an irrigation system. Landscapers also feel sometimes that irrigation products, such as risers, are unsightly intrusions into the landscape design.

So we are often at odds with one another, irrigators and landscapers.

Remember the discussion about Xeriscape in Section 7? Xeriscape is the meeting ground of irrigation and landscaping. Customers are demanding effective, efficient, and economical designs of landscape and irrigation. Landscape preferences are changing rapidly to include efficiency and effectiveness, not just beauty at any cost. Fortunately, irrigation technology is on the zoom and able to keep pace.

It is very important for an irrigator to understand some things about plants, particularly about plant watering requirements. You have to determine the nutrient and water needs of plants and design your irrigation and fertilization system around that, rather than give some blanket coverage and expect high levels of growth.

Learn about landscape design. Talk with landscapers and offer to cooperate with them. Share what you know about irrigation. Together, irrigators and landscapers can produce landscapes that offer the best of both worlds.

Beautification

It is important for the irrigator and the landscaper to understand that beautification is not something that we now do just as a commercial practice. Humans need green things around them for a number of reasons.

Not the least of which is that it is soothing to be in a garden atmosphere. When the wealthy folks of many years past wanted to contemplate how they were going to change the world, they sometimes strolled through hedge mazes in manicured gardens in the countryside.

When you and I think about a pastoral setting, a place where we can get back to nature, so to speak, we think of a garden or a golf course or a park or a woodland setting. We never think about standing on squares of concrete as a soothing place of contemplation. Humans have always leaned toward having green areas around them. This is not all psychological.

We have always tried to culture plants because we need plants as food. Plants freshen our air and dampen sound. The plants around us provide a myriad of benefits, and we are wise enough to recognize that.

So beautification becomes more than an effort in commerce. You beautify real estate not only to make it more valuable, but because it enhances the enjoyment of the property. The beautification is pleasant to look at, has a soothing effect on passers by, and certainly serves the residence better to be in good condition rather than bad.

Where we start getting into some problems is with grandiose designs and landscaping with plant materials that are not indigenous or even well suited to an area. It costs a lot of money and wastes a lot of water. Beautification needs to use water efficiently.

Efficient water use

There are a number of practices that can reduce the amount of water we use to sustain landscape and beautification. First, use automatic controllers and moisture sensors to determine when it is time to water. There is no point in watering to the point of run-off or to apply more inches of water than you would wish for in terms of rain.

Second, use equipment that is designed to conserve water. The Texas Water Development Board helps folks understand that water waste is easily turned into water conservation. They say that sprinklers should be designed to have a low angle of throw, should throw a raindrop-like drop rather than a spray mist or fog, and should be designed to have uniform coverage and predictable precipitation rates.

Third, administer the sprinkler equipment so that you avoid under watering and over watering, particularly over watering because it is a terrible waste of a valuable resource.

Design and install your sprinkler systems in such a way that the moisture gets on plant material, not on paving or other areas where run-off occurs. Water during times when there is low wind and low evaporation rates. Early in the morning is generally the best time to water.

Fourth, take responsibility for instructing the user or the consumer on how best to use water. Sprinklers are a great asset and a great labor saving device, but they can also be a terrible source of water waste. As a professional irrigator, you should be interested in protecting the potable water and in conserving water by using it efficiently.

Laboratory 1

Backflow Prevention Devices

Purpose

This lab allows you to disassemble and reassemble various backflow prevention devices. You can examine the insides of the devices and get a better understanding of how the devices operate and how to service them.

Approximate time to complete lab

Four hours.

Work area required

Fairly large counter tops are best suited for this lab. Individual desks will suffice, but are much less desirable.

Materials required

You (the student) should bring as many of the following items as you have:

Backflow prevention devices
Protective covering for the counter tops, such as
    newspapers, plastic drop cloths, or cloth rags.
    The covering is optional if the lab is being held
    in a shop or other suitable area.
Paper towels or rags
Wrenches
    Open end
    Adjustable
    Socket (optional)
Screwdrivers
    slotted
    phillips
Pliers
    Adjustable-jaw
    Needle nose
    Lock-jaw (optional)
Hammer
Flashlight (optional)

Procedure

Ideally, you should disassemble and reassemble each type of device. The number of students, the number of devices, and the amount of lab time may prevent this. If so, you will have to choose a partner and work in pairs.

Each pair should disassemble and reassemble at least two types of devices. (If there are still more students than devices, you will have to form groups of three, and so on.)

Complete the following steps for this lab. Remember to answer the review questions during the course of the lab.

1. Identify the boxes that contain the backflow prevention devices. Make sure that you return each device to its box at the end of the lab.

2. Help the instructor unpack all of the devices and lay them out in one location.

3. Identify the different types of devices. Discuss some of the advantages and disadvantages of each. Refer to the *Febco* handbook in the appendix if necessary.

4. Find the manufacturer's specifications that accompany each device. Spend about 10 minutes reading through the specifications to get a feel for the type of information in them. Remember: it is always important to read the specifications for any product.

5. Discuss the direction of water flow through each of the devices. Notice the directional arrows on the outside of the devices and think about how the devices prevent flow in the opposite direction.

6. Choose a device to work with and begin disassembling it.

7. Remember to complete the review questions for the lab.

8. Stay aware of the time so that all devices can be reassembled by the end of the class session. If you want to work extra, arrange it with the instructor.

9. As a group activity, discuss the answers to the lab review questions.

Review questions

Answer the following questions based on the discussion and "hands on" work in the lab.

1. How many different types of backflow prevention devices were with the sample goods?

2. How can you recognize the different types? (For each type, list the identifying characteristics. Write across the full width of the page.)

3. How easy or difficult are the devices to disassemble and reassemble? (For each type listed under Question 2, mention whether it was easy or difficult.)

4. What tools were required for each device? Some devices may require only wrenches and screwdrivers; others may require wrenches, screwdrivers, and pliers, etc. (For each type listed under Question 2, mention the tools required.)

5. What did you learn from this lab that you did not already know?

Tips

Sketch any details that you wish to remember about the inside construction of the devices. Be sure to label your drawings as to the type of device.

Notes:

Laboratory 2

Solvent Welding, Soldering, Types of Pipe

Purpose	This lab allows you to practice connecting different types of pipe. You will have hands on experience with compression fittings, solvent welding and soldering. In conjunction, various types of pipe will be discussed.
Approximate time to complete lab	Four hours.
Work area required	A large, open area with few flammable materials is best suited for this lab. The area must be well ventilated--this is vitally important! An exposed cement floor is much preferred over other flooring. If you must work on tile, linoleum, wood, or carpeting, be certain to cover the flooring with a drop cloth or rags.
Safety precautions	Locate the fire extinguisher that is closest to the lab area. Know exactly where it is--in a crisis situation you will not have time to look for it. You must wear goggles and gloves whenever you solder. No exceptions. For example, if only one pair of goggles exists for the class, the whole class must share them, one student at a time. If help avoid this situation, bring your own pair of goggles and gloves. Handle the propane torch safely. Do not point the flame at another person or bring it near any flammable material. Remember that the heat of a torch extends much further than the visible part of the flame.

Materials required

You (the student) should bring as many of the following items as you have.

(You can often get free pieces of scrap plastic and copper pipe from plumbing supply houses and irrigation supply houses. In addition, such supply houses often have free samples of solvents and primers.)

Polyethylene pipe and fittings
Various lengths and diameters of PVC and ABS pipe
Various PVC and ABS fittings to fit the pipe
Various lengths of copper pipe
Various copper fittings to fit the pipe
Protective covering for the floor if it is tile, linoleum, wood, or carpeting. Plastic drop cloths or cloth rags work well.
Heavy work gloves (very important to have your own)
Goggles (very important to have your own)
Paper towels or rags
Various solvents for thermoplastic pipe
Various cleaners or primers for thermoplastic pipe
Hacksaw
Propane torch
Soldering tip for torch
Matches or cigarette lighter
Solder
Flux
Utility knife or pocket knife
Pliers
    Adjustable jaw
    Lock jaw (optional)
Wire cutters
Portable vise (optional, but strongly suggested)
C-clamps (optional, but strongly suggested)
Two foot length of 2X4 or 2X2 (optional, but strongly suggested)

Procedure

Complete the following steps for this lab.

1. Help the instructor unpack the samples of polyethylene pipe and compression fittings from the boxes of irrigation products supplied by the vendors.

2. If you have a knife, help cut the PE pipe into pieces about six inches long. Cut enough pieces for each student to have two pieces.

3. Make sure that you have two pieces and a compression fitting.

4. Attach the two pieces of PE pipe with the compression fitting. When finished, try to pull the two pieces apart by hand.

5. Decide if you want to volunteer to assist the instructor with an experiment. The instructor will explain the experiment at this stage of the lab.

Answer and discuss Review Question 1 before proceeding with Step 6.

6. Help gather the pieces of thermoplastic pipe and fittings, and the solvents and primers. In the process, identify the different types of thermoplastic pipe.

7. Select at least three pieces of pipe and three fittings. The pieces can be short, four to six inches. If the amount of pipe is limited or the pieces are long, you may have to help cut short pieces with a hacksaw.

8. Practice solvent welding the pipe and fittings. Make sure that you are in a ventilated area. If necessary, you may need to review the information on solvent welding in Section 4.

   Complete at least three solvent welds:

   1. Try to weld the pipe and fitting correctly. Set this aside to cure.

   2. Purposely weld the pipe and fitting incorrectly.

   Here are some ways to do it incorrectly: apply an excessive amount of solvent; apply too little solvent; apply solvent without first using primer, and so forth. Be creative--but do it wrong.

   Set the connection aside to cure.

   3. Try once again to weld the pipe and fitting correctly. Set this aside to cure.

9. If the class has enough hacksaws to go around, form groups and make sure that each group has a hacksaw.

For each of the three types of welded samples, cut in half the pipe and fitting. Cut through both the fitting and pipe.

(It is sufficient for each group to cut apart five or six samples. Your group does not need to cut apart all three samples for each member.)

One student may need to hold the pipe and fitting with pliers while another student cuts. Optionally, clamp the pipe and fitting to a 2X4 or 2X2 and rest the board across something (like a desk or counter). One student can hold the board steady while another student cuts.

Answer and discuss Review Questions 2 and 3 before proceeding with Step 10.

10. Select at least three pieces of copper pipe and three copper fittings. The pipe pieces should be at least six inches long. If the amount of pipe is limited or the pieces are long, you may have to help cut short pieces with a hacksaw.

Important: Because of using short pieces, one student will need to hold the pipe with pliers while another student practices soldering. Remember that the student holding the pipe must stand to the side of the flame, not directly in front of it.

Optionally, clamp the pipe and fitting to a 2X4 or 2X2 and rest the board across something (like a desk or counter). One student can hold the board steady while another student cuts.

11. Practice soldering the pipe and fittings. If necessary, you may need to review the information on soldering in Section 4.

Solder at least three connections:

1. Try to solder the pipe and fitting correctly. Set this aside to cool.

2. Purposely solder the pipe and fitting incorrectly.

Here are some ways to do it incorrectly: overheat the fitting ("cook" it until it turns blue); apply the solder to the same side of the fitting as the torch (before the side opposite the torch has had a chance to heat); apply the solder with using flux; rough up the end of the pipe with sandpaper or a file before soldering it to the fitting, and so forth.

Set the connection aside to cool.

3. Try once again to weld the pipe and fitting correctly. Set this aside to cool.

12. If you have enough hacksaws to go around, form groups and make sure that each group has a hacksaw.

For each of the three types of soldered samples, cut in half the pipe and fitting. Cut through both the fitting and pipe, very near the actual solder connection itself.

(It is sufficient for each group to cut apart five or six samples. Your group does not need to cut apart all three samples for each member.)

One student may need to hold the pipe and fitting with pliers while another student cuts. Optionally, clamp the pipe and fitting to a 2X4 or 2X2 and rest the board across something (like a desk or counter). One student can hold the board steady while another student cuts.

Answer and discuss Review Questions 4 and 5 before proceeding with Step 13.

13. If time permits, practice some more on solvent welding or soldering. Choose the one that you are least comfortable doing.

14. Help to clean the lab. If you rearranged furniture or equipment, place it back as you found it.

15. Answer Review Question 6. If you have questions or comments about any of the review questions, share them with the group.

Review questions

Answer the following questions based on the discussion and "hands on" work in the lab.

1. Was anyone in class able to pull apart the PE pipe and compression fitting? If so, describe where the separation occurred (did the pipe pull loose from the fitting or did the fitting itself separate, etc.)

2. What is your reaction to solvent welding? Is is easier than you expected? Why? More difficult? Why? Do you feel comfortable with solvent welding, or do you need more practice?

3. What did the solvent welded bonds look like after you cut in half the pipe and fitting? Describe the differences between the correctly welded connection and the incorrectly welded one.

4. What is your reaction to soldering? Is is easier than you expected? Why? More difficult? Why? Do you feel comfortable with soldering, or do you need more practice?

5. What did the soldered bonds look like after you cut in half the pipe and fitting? Describe the differences between the correctly soldered connection and the incorrectly soldered one.

6. What did you learn from this lab that you did not already know? Be specific.

Notes:

Laboratory 3

Drip Irrigation

Purpose	This lab allows you to assemble and disassemble various drip irrigation components. You can examine the components and get a better understanding of how they operate and how to service them.
Approximate time to complete lab	Three hours.
Work area required	An outside area with access to a hose bibb is required for this lab. In addition, an inside area with fairly large counter tops is strongly recommended.
Materials required	Paper towels or rags Screwdrivers slotted Pliers Adjustable-jaw Hammer Utility knife

Procedure

Complete the following steps for this lab.

1. Help the instructor to identify the boxes that contain the drip irrigation products. Make sure that you return each device to its box at the end of the lab.

2. Help the instructor to unpack all of the products and lay them out in one location.

3. Identify the different types of products.

   Get a copy of the manufacturer's specifications that accompany the products. Spend about 10 minutes reading through the specifications to get a feel for the types of information in them.

4. Disassemble some of the emitters. This may require cracking the emitters with a hammer. Look at the path of water flow through the emitters and discuss how the emitter achieves pressure loss.

5. Cut open some the double-walled tubing and inspect the 2 chambers.

6. Assemble 1 on the drip kits. Attach the kit to a hose bibb and run water through the system.

7. If time allows, and a suitable area is available, bury 1 strip of the double-walled tubing and run water through it for a short while. Dig down into the soil and observe the type of watering pattern produced.

8. Determine how well the pressure regulators work. For example, attach 2 or more regulators together and see if the pressure is reduced proportionately.

9. Answer the lab review questions.

Review questions

Answer the following questions based on the discussion and "hands on" work in the lab.

1. How many different types of drip irrigation products were with the sample goods? Describe them.

2. Describe the different types of emitters. How do they achieve pressure loss to regulate flow?

3. How easy or difficult was the drip kit to assemble? Describe the water flow and pattern(s) from the kit.

4. Were the pressure regulators effective? Describe the effects of using 2 or more regulators together.

5. What did you learn from this lab that you did not already know?

Tips

Sketch any details that you wish to remember about drip products. Be sure to label your drawings.

Laboratory 4

Irrigation Equipment

Purpose	This lab allows you to become familiar with various equipment used in the irrigation business. You can see demonstrations of the equipment and ask questions about how to operate and service the equipment.
Approximate time to complete lab	Four hours.
Lab area required	An outside area where the irrigation equipment can be demonstrated.
Materials required	Vehicles to transport the students to various vendor locations (See Step 1 below)

Procedure

Complete the following steps for this lab.

1. Find out from your instructor which types of irrigation equipment you will see demonstrated, and where.

2. If necessary, travel to the vendor's location for a demonstration of the equipment. Try to see demonstrations of at least two different pieces of equipment. If supervised by and acceptable to the vendor, operate the equipment.

3. If possible, tour at least one plumbing/irrigation supply house (more if available).

   Visit with the owner/manager(s) of the supply house(s) and find out what products the vendor(s) stocks.

4. If possible, visit at least one job site where a sprinkler system is currently being installed. The system can be residential or commercial. If you are employed in the irrigation business, try to visit one of the systems being installed by your company.

5. Answer the lab review questions.

Review questions

Answer the following questions based on the discussion and "hands on" work in the lab.

1. How many different types of irrigation equipment did you see demonstrated? Describe them.

2. If you were allowed to operate any of the equipment, what was the easiest part about the operation? The most difficult?

3. What types of irrigation products did the plumbing/irrigation supply house(s) carry? Did the owner/manager(s) seem knowledgeable about the irrigation business? Why or why not.

4. What did you learn from this lab that you did not already know?

Notes:

Drawing Exercise 1

Laying Out Heads

Purpose	This drawing exercise allows students to become familiar with their drawing instruments and to practice triangulation and head placement.
Plot plan used for this exercise	Plot Plan 1 (the instructor will distribute it during class)
Approximate time to complete drawing	Four hours.
Materials required	Drawing compass Engineer scale (10 scale ruler) Eraser Template (optional) Triangle (optional)
Conditions affecting the design	The property owner does not want water thrown on the house, driveway, sidewalk, patio, or fence. The valves may be located throughout the yard.

Procedure

Complete the following steps for this drawing exercise:

1. Determine the type of heads and the size and shape of patterns that you will use for the plot plan.
2. Lay out the heads based on the conditions affecting the design.
3. Use triangulation to correctly space the heads and rows.
4. Answer the review questions.

Review questions

Answer the following questions based on class discussion and "hands on" work with the drawing.

1. What was the most difficult part about this drawing exercise?

2. What did you learn about layout from looking at the layouts of the other students?

3. Think about your layout in terms of square and round patterns. How would the layout differ if you used square patterns (if you did not use any)? How would it differ if you used round patterns (if you did not use any)?

4. What did you learn from this drawing exercise that you did not already know? Be specific.

Notes:

Drawing Exercise 2

Sectioning the System

Purpose	This drawing exercise allows students to layout the main line and lateral lines, size the piping, and calculate the pressure loss for the sprinkler system.
Plot plan used for this exercise	Plot Plan 1 (same plot plan as used for Drawing Exercise 1)
Approximate time to complete drawing	Four hours.
Materials required	Drawing compass Engineer scale (10 scale ruler) Eraser Template (optional) Triangle (optional) Calculator
Conditions affecting the design	The property owner does not want water thrown on the house, driveway, sidewalk, patio, or fence. The valves may be located throughout the yard.

Procedure

Complete the following steps for this drawing exercise:

Note: You may need to review Section 6 in your Guide, and pages 99 through 108 in the ABC's before starting this exercise.

1. Determine the static pressure and the size and flow rate of the water meter. Apply the 75% rule to the supply volume.

2. List the types of sprinklers that you are using, their discharge rates, and their minimum and maximum operating pressures.

3. Divide the sprinklers into sections, starting at the source of the water supply.

4. Estimate where the main supply line will run (you can change it later if necessary).

5. Calculate the friction loss for the farthest section and for the largest section by using the "quick check" method.

   You will need to refer to pressure loss tables such as those distributed by the instructor for Drawing Exercise 1.

6. Add the piping (after you have successfully sectioned the heads).

   Do not size the pipe yet.

7. Add the valves

   A reasonable practice is to put the remote control valve somewhere close to the middle of its circuit. This gives you have a consistent pressure drop from the center to either end. In all cases, you cannot locate it near the center.

8. Route the main supply line.

9. Size the pipe and valves.

   When sizing pipe, use the smallest pipe that can safely carry the amount of water that has to pass through it.

10. Answer the review questions.

Review questions

Answer the following questions based on class discussion and "hands on" work with the drawing.

1. What was the most difficult part about this drawing exercise?

2. Did you find that you needed to change the layout of the sprinkler heads when you began to section the system? If so, explain.

3. Think about your drawing in terms of square and round patterns. How would the piping differ if you used square patterns (if you did not use any)? How would it differ if you used round patterns (if you did not use any)?

4. What did you learn from this drawing exercise that you did not already know? Be specific.

Drawing Exercise 3

Pricing the Components

Purpose	This drawing exercise allows students to route the wire for a sprinkler system and to locate the controller. In addition, the students will price the various components used in the sprinkler system.
Plot plan used for this exercise	Plot Plan 1 (same plot plan as used for Drawing Exercises 1 and 2)
Approximate time to complete drawing	Four hours.
Materials required	Pencil Drawing compass Engineer scale (10 scale ruler) Eraser Template (optional) Triangle (optional) Calculator Price information
Conditions affecting the design	The property owner does not want water thrown on the house, driveway, sidewalk, patio, or fence. The valves may be located throughout the yard.

Procedure

Complete the following steps for this drawing exercise.

Note: You may need to review pages 110 through 114 in the ABC's before starting this exercise.

1. Make sure that you have completed Drawing Exercises 1 and 2 before continuing with this exercise.
2. Determine where you will locate the controller for the irrigation system.
3. Route the wire from all of the valves to the controller.
4. List the types of irrigation components used in your system design, including backflow prevention device(s), valves, heads, pipe, fittings, controller, and miscellaneous parts.
5. Determine the total cost of the components in the system. If necessary, contact a plumbing/irrigation supply house and get price information.
6. Determine how much labor you would charge for the system. Remember to consider such things as how the system was installed, by hand, trencher, vibraplow, etc.
7. Determine a total cost of the system that you would present to the property owner.
8. Answer the review questions.

Review questions

Answer the following questions based on class discussion and "hands on" work with the drawing.

1. What was the most difficult part about this drawing exercise?

2. Did you find that you needed to change the layout when you located the controller and ran wire? If so, explain.

3. What was the most difficult part about pricing the system? The easiest? Be specific.

4. What did you learn from this drawing exercise that you did not already know? Be specific.

Notes:

Drawing Exercise 4

Designing a Complete System

Purpose

This drawing exercise allows students to design a complete system from beginning to end. It is the equivalent of Drawing Exercises 1, 2, and 3.

The students will practice triangulation and head placement, layout the main line and lateral lines, size the piping, calculate the pressure loss for the sprinkler system, route the wire, locate the controller, and price the various components used in the sprinkler system.

Plot plan used for this exercise

Plot Plan 2 (the instructor will provide copies to the students)

Approximate time to complete drawing

Eight hours.

Materials required

Pencils
Drawing compass
Engineer scale (10 scale ruler)
Eraser
Template (optional)
Triangle (optional)
Calculator
Price information

Conditions affecting the design

The property owner does not want water thrown on the house, driveway, sidewalk, patio, or fence.

The valves must be located at a central manifold near the house.

The property owner wants drip irrigation used where applicable.

Procedure

Complete the following steps for this drawing exercise:

Note: You may need to review Section 6 in your Guide, and pages 99 through 114 in the ABC's before starting this exercise.

1. Determine the type of heads and the size and shape of patterns that you will use for the plot plan.
2. Lay out the heads based on the conditions affecting the design.
3. Use triangulation to correctly space the heads and rows.
4. Determine the static pressure and the size and flow rate of the water meter. Apply the 75% rule to the supply volume.
5. List the types of sprinklers that you are using, their discharge rates, and their minimum and maximum operating pressures.
6. Divide the sprinklers into sections, starting at the source of the water supply.
7. Estimate where the main supply line will run (you can change it later if necessary).
8. Calculate the friction loss for the farthest section and for the largest section by using the "quick check" method.

You will need to refer to pressure loss tables such as those distributed by the instructor for Drawing Exercise 1.

9. Add the piping (after you have successfully sectioned the heads).

   Do not size the pipe yet.

10. Add the valves

    A reasonable practice is to put the remote control valve somewhere close to the middle of its circuit. This gives you have a consistent pressure drop from the center to either end. In all cases, you cannot locate it near the center.

11. Route the main supply line.

12. Size the pipe and valves.

    When sizing pipe, use the smallest pipe that can safely carry the amount of water that has to pass through it.

13. Determine where you will locate the controller for the irrigation system.

14. Route the wire from all of the valves to the controller.

15. List the types of irrigation components used in your system design, including backflow prevention device(s), valves, heads, pipe, fittings, controller, drip irrigation parts, and miscellaneous parts.

16. Determine the total cost of the components in the system. If necessary, contact a plumbing/irrigation supply house and get price information.

17. Determine how much labor you would charge for the system. Remember to consider such things as how the system was installed, by hand, trencher, vibraplow, etc.

18. Determine a total cost of the system that you would present to the property owner.

19. Answer the review questions.

Review questions

Answer the following questions based on class discussion and "hands on" work with the drawing.

1. What was the most difficult part about this drawing exercise?

2. Did you find that you needed to change the layout for any reason? If so, explain.

3. Think about your drawing in terms of square and round patterns. How would the piping differ if you used square patterns (if you did not use any)? How would it differ if you used round patterns (if you did not use any)?

4. What did you learn from this drawing exercise that you did not already know? Be specific.

Notes:

TEXAS BOARD OF IRRIGATORS

PERMANENT RULES
AND
LICENSED IRRIGATORS ACT

P.O. Box 12337
Capitol Station
Austin, Texas 78711

THE

TEXAS BOARD OF IRRIGATORS

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THE BOARD'S PERMANENT RULES AND LICENSED IRRIGATORS ACT

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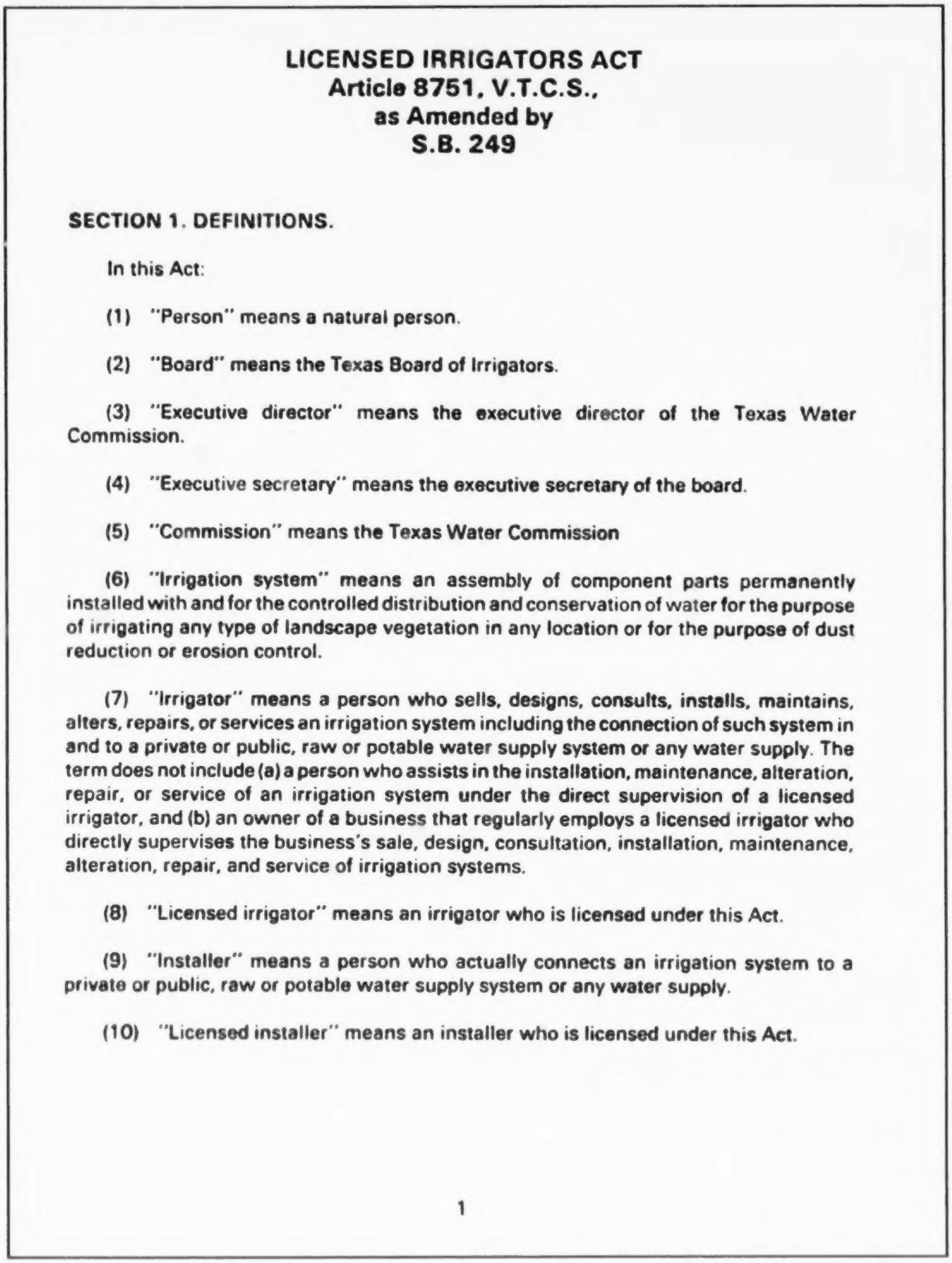


LICENSED IRRIGATORS ACT
Article 8751, V.T.C.S.,
as Amended by
S.B. 249

SECTION 1. DEFINITIONS.

In this Act:

(1) "Person" means a natural person.

(2) "Board" means the Texas Board of Irrigators.

(3) "Executive director" means the executive director of the Texas Water Commission.

(4) "Executive secretary" means the executive secretary of the board.

(5) "Commission" means the Texas Water Commission

(6) "Irrigation system" means an assembly of component parts permanently installed with and for the controlled distribution and conservation of water for the purpose of irrigating any type of landscape vegetation in any location or for the purpose of dust reduction or erosion control.

(7) "Irrigator" means a person who sells, designs, consults, installs, maintains, alters, repairs, or services an irrigation system including the connection of such system in and to a private or public, raw or potable water supply system or any water supply. The term does not include (a) a person who assists in the installation, maintenance, alteration, repair, or service of an irrigation system under the direct supervision of a licensed irrigator, and (b) an owner of a business that regularly employs a licensed irrigator who directly supervises the business's sale, design, consultation, installation, maintenance, alteration, repair, and service of irrigation systems.

(8) "Licensed irrigator" means an irrigator who is licensed under this Act.

(9) "Installer" means a person who actually connects an irrigation system to a private or public, raw or potable water supply system or any water supply.

(10) "Licensed installer" means an installer who is licensed under this Act.

SECTION 2. EXEMPTIONS.

This Act does not apply to:

(1) any person licensed by the Texas State Board of Plumbing Examiners;

(2) a registered professional engineer or architect or landscape architect if his or her acts are incidental to the pursuit of his or her profession;

(3) irrigation or yard sprinkler work done by a property owner in a building or on premises owned or occupied by him or her as his or her home;

(4) irrigation or yard sprinkler work done by a maintenance person incidental to and on premises owned by the business in which he or she is regularly employed or engaged and who does not engage in the occupation of licensed irrigator or in yard sprinkler construction or maintenance for the general public;

(5) irrigation or yard sprinkler work done on the premises or equipment of a railroad by a regular employee of the railroad who does not engage in the occupation of licensed irrigator or in yard sprinkler construction or maintenance for the general public;

(6) irrigation and yard sprinkler work done by a person who is regularly employed by a county, city, town, special district, or political subdivision of the state on public property;

(7) a temporary or portable water device such as a garden hose, hose sprinkler, soaker hose, or agricultural irrigation system;

(8) a portable or solid set or other type of commercial agricultural irrigation system; or

(9) irrigation or yard sprinkler work done by an agriculturist, agronomist, horticulturist, forester, gardener, contract gardener, garden or lawn caretaker, nurseryman, or grader or cultivator of land on land owned by himself or herself.

SECTION 3. TEXAS BOARD OF IRRIGATORS.

(a) There is created a Texas Board of Irrigators composed of six members, each of whom shall be a citizen of the United States and a resident of this state.

(b) Each member of the board and his or her successor shall be appointed by the governor with the advice and consent of the senate. Two members shall be members of the public not licensed under this Act, and four members shall be licensed irrigators who have been actively engaged in the practice of irrigation of the type licensed under this Act for a period of at least five years. Appointments to the board shall be made without regard to the race, creed, sex, religion, or national origin of the appointees.

(c) Except for the initial appointees to the board, the members of the board hold office for terms of six years, with the terms of two members expiring on January 31 of each odd-numbered year. In making initial appointments, the governor shall designate two members to serve terms expiring January 1, 1981, two members to serve terms expiring January 31, 1983, and two members to serve terms expiring January 31, 1985.

(d) The board shall select one of its members as chairman. The Chairman shall serve for the term provided by the rules of the board and may be removed for cause, but his or her removal does not disqualify him or her from continuing as a member of the board.

(e) Four members of the board constitute a quorum for transaction of business.

(f) The initial board shall hold its first meeting within 30 days after all members have qualified, and the board shall hold at least two regular meetings each year at a time and place designated by the chairman. The board may hold special meetings at times and places considered necessary by a majority of the members of the board.

(g) Each member shall receive as compensation for his or her services an amount provided by the General Appropriations Act for each day he or she is actively engaged in official duties in addition to actual travel expenses.

(h) It is a ground for removal of a member from the board that the member does not attend at least one-half of the regularly scheduled meetings held by the board in a calendar year.

SECTION 4. CONFLICT OF INTEREST.

A member of the board may not be an officer, employee, or paid consultant of a trade association in the field of landscape irrigation. No board member may be related within the second degree by affinity or within the second degree by consanguinity to a person who is an officer, employee, or paid consultant of a trade association in the irrigation industry.

SECTION 5. EXECUTIVE SECRETARY; EMPLOYEES.

(a) The board may employ an executive secretary to perform the duties and functions provided by this Act and as directed by the board.

(b) The executive director shall provide necessary services to assist the executive secretary and the board in performing their duties and functions under this Act.

(c) The commission shall hear all contested cases as defined in the Administrative Procedure and Texas Register Act, as amended (Article 6252-13a, Vernon's Texas Civil Statutes), arising under this Act. The board is subject to the open meetings law, Chapter 271, Acts of the 60th Legislature, Regular Session, 1967, as amended (Article 6252-17, Vernon's Texas Civil Statutes), and the Administrative Procedure and Texas Register Act, as amended (Article 6252-13a, Vernon's Texas Civil Statutes).

(d) A person who is required to register as a lobbyist under Chapter 422, Acts of the 63rd Legislature, Regular Session, 1973, as amended (Article 6252-9c, Vernon's Texas Civil Statutes), may not act as the general counsel to the board.

SECTION 6. BOARD FINANCES.

(a) Money paid to the board under this Act shall be deposited in the State Treasury in a special fund known as the Texas Board of Irrigator's Fund.

(b) The Texas Board of Irrigators Fund shall be used to pay expenses under this Act.

(c) Before September 1 of each year, the board shall make a written report to the governor accounting for all receipts and disbursements under this Act.

SECTION 7. RULES.

(a) The board shall adopt only those rules consistent with this Act to govern the conduct of its business and proceedings and shall adopt standards governing revocation of certificates of registration and connections to public or private water supplies by a licensed irrigator or a licensed installer.

(b) The board does not have authority to amend or enlarge by rule on any provision of this Act, to change the meaning of this Act by rule in any manner, to adopt a rule that is contrary to the underlying and fundamental purposes of this Act, or to make a rule that is unreasonable, arbitrary, capricious, illegal, or unnecessary.

(c) The board shall adopt no rules which would preclude advertising or competitive bidding.

(d) If the appropriate standing committee of either house of the legislature acting under Subsection (g), Section 5, Administrative Procedure and Texas Register Act, as added (Article 6252-13a, Vernon's Texas Civil Statutes), transmits to the board statements opposing adoption of a rule under that section, the rule may not take effect, or if the rule has already taken effect, the rule is repealed effective on the date the board receives the committee's statements.

SECTION 8. REGISTRATION REQUIREMENT.

(a) No person may act as an irrigator or installer unless he or she has a valid certificate of registration under this Act.

(b) The board shall issue certificates of registration to persons of good moral character who have shown themselves fit, competent, and qualified to act as licensed irrigators or licensed installers by passing a uniform, reasonable examination which will include the principles of cross connections and safety devices to prevent contamination of potable water supplies.

(c) The board shall provide in its rules for the preparation, administration, and grading of examinations to acquire certificates of registration under this Act. The fee for taking the examination shall be set by the Board not to exceed $100 for the irrigator certificate of registration and not to exceed $75 for the installer certificate of registration.

(d) A person holding a certificate of registration under this Act shall not be required to comply with any other licensing requirements of other state agencies to perform connections to private or public raw or potable water supply systems.

(e) Not later than the 30th day after the day on which a person completes an examination administered by the board, the board shall send to the person his or her examination results. If requested in writing by a person who fails the examination, the board shall send to the person not later than the 30th day after the day on which the request is received by the board an analysis of the person's performance on the examination.

SECTION 9. RECIPROCITY.

(a) The board may certify for registration without examination an applicant who is registered as a licensed irrigator or licensed installer in another state or country that has requirements for registration that are at least substantially equivalent to the requirements of this state and that extends the same privilege of reciprocity to licensed irrigators or licensed installers registered in this state.

(b) The application for registration under this section shall be accompanied by a fee of not to exceed $100 for a licensed irrigator or $75 for a licensed installer as determined by the board.

SECTION 10. RENEWAL.

(a) Certificates of registration expire on August 31 of each year.

(b) The board or the executive secretary shall notify every person registered under this Act of the date of expiration of his or her certificate and the amount of the fee that is required for renewal for one year. The notice shall be mailed at least two months in advance of the date of expiration of the certificate.

(c) A person may renew his or her certificate at any time during the months of July and August of each year by payment of the fee adopted by the board in an amount of not more than $150 for a licensed irrigator or $100 for a licensed installer.

(d) Failure of a registrant to renew his or her certificate by August 31 does not deprive the registrant of the right to renewal, but the fee paid for renewal of a certificate after the August 31 expiration date shall be increased 10 percent for each month or part of a month that renewal payment is delayed. If the registrant fails to renew within 90 days after the date of expiration of the registration certificate, the registrant must reapply for registration and must qualify under Section 8 of this Act to act as a licensed irrigator or licensed installer.

(e) Renewal certificates carry the same registration number as the original certificates.

(f) By rule, the board may adopt a system under which certificates of registration may expire on various dates during the year. Renewals may be made at any time during the two-month period before the designated expiration date, and renewal fees paid after the expiration date shall be increased 10 percent for each month or part of a month that renewal payment is delayed. If a registrant fails to renew within 90 days after the expiration date of the registration, the registrant must reapply for registration and must qualify under Section 8 of this Act to act as a licensed irrigator or a licensed installer. For the year in which the expiration date is changed, registration fees payable on August 31 shall be prorated on a monthly basis so that each registrant will pay only that portion of the registration fee that is allocable to the number of months during which the registration is valid, and on renewal of the registration on the new expiration date, the total of the registration fee is payable.

SECTION 11. REVOCATION.

(a) The commission may revoke a certificate of registration of any registrant whom it finds guilty of:

(1) violations of this Act or rules adopted under this Act;

(2) fraud or deceit in obtaining a certificate of registration; or

(3) gross negligence, incompetency, or misconduct while acting as a licensed irrigator or licensed installer.

(b) The commission shall hear complaints under Subsection (a) of this section subject to standards adopted by the board in its rules.

(c) Any person may file a complaint with the board. The complaint shall be in writing, shall be notarized, and shall set forth the facts alleged. Three copies of the written allegations shall be filed with the executive director. One copy shall be sent by certified mail to the alleged violator.

(d) On receipt of written allegations, the board, if it considers the information sufficient to support further action, shall issue an order referring the complaint to the commission for setting a hearing.

(e) If the executive director determines through investigation that evidence exists of a violation, he may refer such evidence to the board or may proceed directly to the commission to request setting of a hearing.

(f) The commission may compel the attendance of a witness before it as in civil cases in the district court by issuance of a subpoena.

SECTION 12. PENALTY; INJUNCTION.

(a) A person who represents himself or herself as a licensed irrigator or licensed installer in this state without being licensed or exempted under this Act, who presents or attempts to use as his or her own the certificate of registration or the seal of another person who is a licensed irrigator or licensed installer, who gives false or forged evidence of any kind to the board or to any member of the board in obtaining or assisting in obtaining for another a certificate of registration, shall be guilty of a Class C misdemeanor. Each day a violation of this subsection occurs constitutes a separate offense.

(b) A person who violates this Act or a rule or order of the commission adopted under this Act is subject to a civil penalty of not to exceed $1,000 for each offense. Each day a violation is committed is a separate offense.

(c) An action to recover the penalty under Subsection (b) of this section may be brought by the board in any court of competent jurisdiction in the county in which the offending activity occurred, in which the defendant resides, or in Travis County.

(d) The board may enforce this Act or a valid rule or order of the commission by injunction or other appropriate remedy. The action may be brought by the board in a court of competent jurisdiction in the county in which the offending activity occurred, in which the defendant resides, or in Travis County.

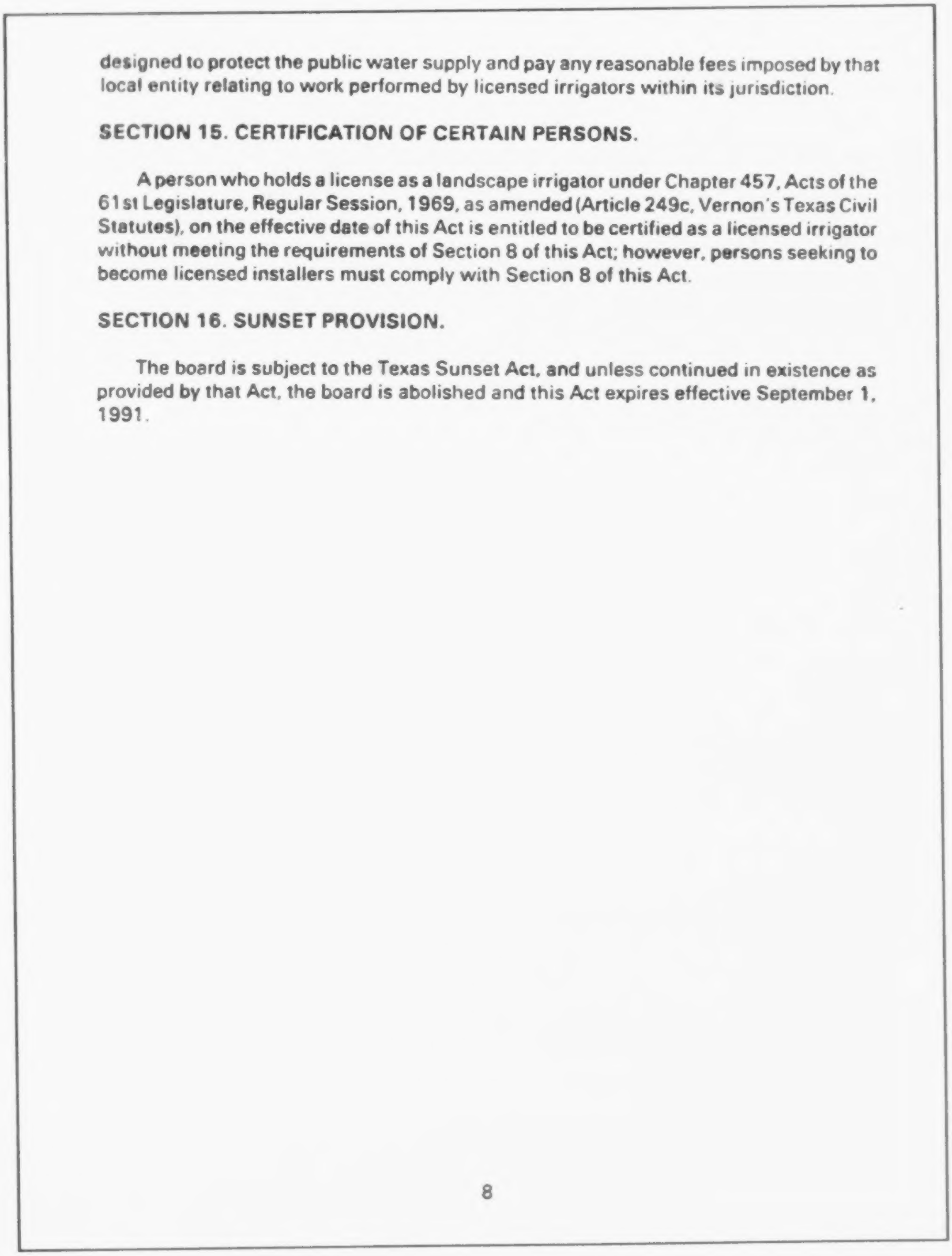
(e) At the request of the board, the attorney general shall institute and conduct a suit in the name of the state to recover the civil penalty as provided under Subsection (b) of this section, or for injunctive relief or other appropriate remedy, or for both.

SECTION 13. ENFORCEMENT OF ACT.

The executive director with the assistance of the attorney general shall enforce this Act and the rules adopted by the board.

SECTION 14. LOCAL RULES AND REGULATIONS.

The regulatory authority of any city, town, county, special purpose district, or other political subdivision of the state may require licensed irrigators or licensed installers to comply with any reasonable inspection requirements or ordinances and regulations



designed to protect the public water supply and pay any reasonable fees imposed by that local entity relating to work performed by licensed irrigators within its jurisdiction.

SECTION 15. CERTIFICATION OF CERTAIN PERSONS.

A person who holds a license as a landscape irrigator under Chapter 457, Acts of the 61st Legislature, Regular Session, 1969, as amended (Article 249c, Vernon's Texas Civil Statutes), on the effective date of this Act is entitled to be certified as a licensed irrigator without meeting the requirements of Section 8 of this Act; however, persons seeking to become licensed installers must comply with Section 8 of this Act.

SECTION 16. SUNSET PROVISION.

The board is subject to the Texas Sunset Act, and unless continued in existence as provided by that Act, the board is abolished and this Act expires effective September 1, 1991.

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Appendix B - Permanent Rules

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NOTICE: These rules are current as of the final publishing date of April, 1984, but are subject to change pursuant to the procedures established in the Texas Administrative Procedure and Texas Register Act.

Texas Board of Irrigators
Introductory Provisions

GENERAL PROVISIONS
§§421.1-421.4

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§421.1. DEFINITIONS.

The following words and terms, when used in this Part XIV, shall have the following meanings, unless the context clearly indicates otherwise:

(1) "Board" means the Texas Board of Irrigators.

(2) "Commission" means the Texas Water Commission.

(3) "Complainant" means anyone who has filed with the board a notarized complaint which states matters within the board's jurisdiction.

(4) "Executive director" means the executive director of the Texas Water Commission.

(5) "Executive secretary" means the executive secretary of the board.

(6) "Installer" means a person who actually connects an irrigation system to a private or public, raw or potable water supply system or any water supply.

(7) "Irrigation system" means an assembly of component parts permanently installed with and for the controlled distribution and conservation of water for the purpose of irrigating any type of landscape vegetation in any location or for the purpose of dust reduction or erosion control.

(8) "Irrigator" means a person who sells, designs, consults, installs, maintains, alters, repairs, or services an irrigation system including the connection of such system in and to a private or public, raw or potable water supply system or any water supply. The term does not include (a) a person who assists in the installation, maintenance, alteration, repair, or service of an irrigation system under the direct supervision of a licensed irrigator, and (b) an owner of a business that regularly employs a licensed irrigator who

directly supervises the business's sale, design, consultation, installation, maintenance, alteration, repair, and service of irrigation systems.

(9) "Licensed installer" means an installer registered under Texas Civil Statutes, Article 8751, pursuant to these sections.

(10) "Licensed irrigator" means an irrigator registered under Texas Civil Statutes, Article 8751, pursuant to these sections.

(11) "Person" means a natural person.

(12) "Respondent" means anyone against whom a notarized complaint, which states matters within the board's jurisdiction, has been filed with the board.

§421.4. PURPOSE.

The purposes of the provisions of this Part XIV are to implement the powers and duties assigned to the Texas Board of Irrigators, and its executive secretary by Texas Civil Statutes, Article 8751 and other laws of this state, and to establish the general policies which are specifically applicable to the board. The provisions of this Part XIV shall be given a reasonable, fair, and impartial interpretation.

Texas Board of Irrigators
Introductory Provisions

GENERAL PROVISIONS AFFECTING BOARD
§§421.21-421.48

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§421.21. OFFICE; MAILING ADDRESS.

The official place of business of the board shall be the office of its executive secretary in the Stephen F. Austin State Office Building in Austin, Texas. The official mailing address of the board shall be P.O. Box 12337, Austin, Texas 78711.

§421.24. PERSON FOR SERVICE OF PROCESS.

The executive secretary, at the address of the board's official place of business, shall be the person upon whom service of process may be served in judicial proceedings against the board.

§421.27. OFFICIAL SEAL.

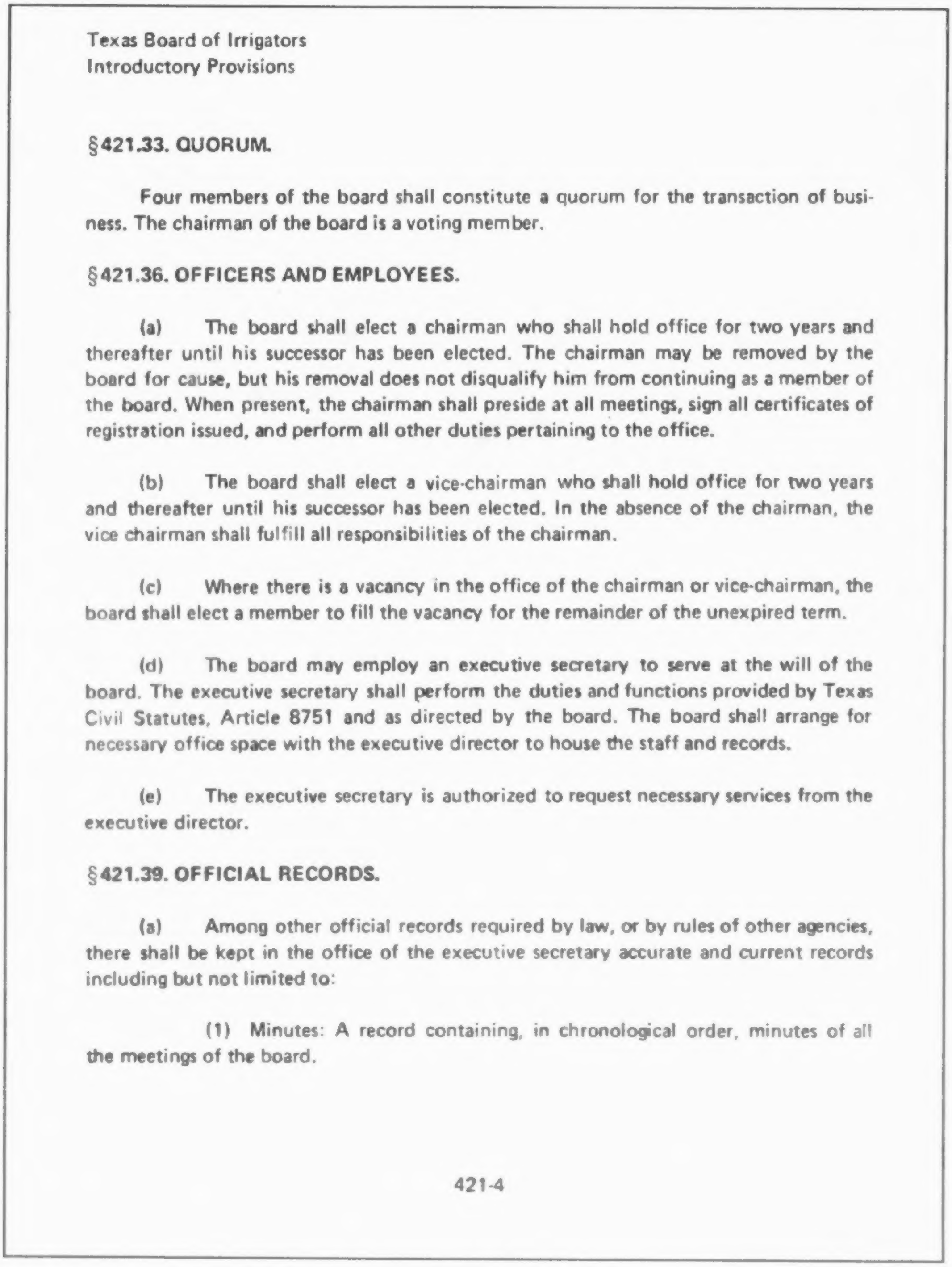
The official seal of the board will bear the words "Texas Board of Irrigators" encircling the oak and olive branches common to other official seals.

§421.30. MEETINGS AND NOTICES THEREOF.

(a) The board shall hold at least two regular meetings each year at times and places designated by its chairman.

(b) The board may hold other meetings at times and places considered necessary by a majority of the members of the board or the chairman of the board.

(c) The board shall give notice of its meetings and shall hold its meetings in accordance with the open meetings law, Texas Civil Statutes, Article 6252-17.



Texas Board of Irrigators
Introductory Provisions

§421.33. QUORUM.

Four members of the board shall constitute a quorum for the transaction of business. The chairman of the board is a voting member.

§421.36. OFFICERS AND EMPLOYEES.

(a) The board shall elect a chairman who shall hold office for two years and thereafter until his successor has been elected. The chairman may be removed by the board for cause, but his removal does not disqualify him from continuing as a member of the board. When present, the chairman shall preside at all meetings, sign all certificates of registration issued, and perform all other duties pertaining to the office.

(b) The board shall elect a vice-chairman who shall hold office for two years and thereafter until his successor has been elected. In the absence of the chairman, the vice chairman shall fulfill all responsibilities of the chairman.

(c) Where there is a vacancy in the office of the chairman or vice-chairman, the board shall elect a member to fill the vacancy for the remainder of the unexpired term.

(d) The board may employ an executive secretary to serve at the will of the board. The executive secretary shall perform the duties and functions provided by Texas Civil Statutes, Article 8751 and as directed by the board. The board shall arrange for necessary office space with the executive director to house the staff and records.

(e) The executive secretary is authorized to request necessary services from the executive director.

§421.39. OFFICIAL RECORDS.

(a) Among other official records required by law, or by rules of other agencies, there shall be kept in the office of the executive secretary accurate and current records including but not limited to:

(1) Minutes: A record containing, in chronological order, minutes of all the meetings of the board.

(2) List of registrants: A list containing the name, last known address and registration number of all persons who hold certificates of registration which are currently renewed.

(3) Registrant records: An individual record for each registrant containing the original application, relevant verification and evaluation data, examination and grade records, the date of registration, and a record of annual renewals and fees received after registration, and when applicable, a record of alleged violations, suspensions, and revocations.

(4) Budget Records: Records showing funds budgeted, committed, spent, and remaining, and projects of appropriate requests for consideration in budget development, as well as financial records required by various state agencies.

(b) Subject to the limitations and exceptions provided under the Open Records Act, Texas Civil Statutes, Article 6252-17a, information collected, assembled, or maintained by the board or its executive secretary is public information open to inspection and copying during regular business hours.

§421.42. SIGNING CERTIFICATES.

Each certificate of registration shall be signed by the chairman and vice-chairman of the board and shall bear the seal of the Texas Board of Irrigators.

§421.45. LIAISON WITH SECRETARY OF STATE.

The executive secretary shall be the liaison through whom all required documents may be submitted on behalf of the board to the secretary of state for filing and publication. The executive secretary may designate one or more persons to act as liaison in the executive secretary's absence.

§421.48. IRRIGATION STANDARDS AND TESTING PROCEDURES.

The board shall remain current on national irrigation testing procedures as well as national and local requirements governing irrigation systems.

Texas Board of Irrigators
Registration of Irrigators and Installers

APPLICATION FOR REGISTRATION
§§423.1-423.22

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§423.1. ELIGIBILITY FOR CERTIFICATES OF REGISTRATION.

(a) The board may issue certificates of registration only to individuals who are eligible for registration as licensed irrigators or licensed installers under Texas Civil Statutes, Article 8751 and these sections. No certificate of registration may be issued to any firm, partnership, corporation, or other group of persons.

(b) No individual is eligible to receive a licensed irrigator's or licensed installer's certificate of registration unless he has applied for it pursuant to these sections and:

(1) the board has determined that he is a person of good moral character who has passed a uniform, reasonable examination for irrigators or installers, as applicable, administered by the board in accordance with these sections; or

(2) the board has determined that he is a person registered as the equivalent of a licensed irrigator or licensed installer in another state or country that has requirements for registration that are substantially equivalent to the requirements of Texas and that extends the same privilege of reciprocity to licensed irrigators or licensed installers registered in Texas.

§423.4. APPLICATIONS FOR CERTIFICATES OF REGISTRATION.

(a) Every person applying for a licensed irrigator's or licensed installer's certificate of registration shall complete a required application form and submit it to the executive secretary with the required application or examination fee.

(b) In addition to submitting his completed application form and application fee, an irrigator or installer holding a certificate of registration in another state or country who wishes to be considered for registration in Texas under reciprocity, shall submit to the executive secretary his certification record from the state or country in which he is registered.

(c) Upon request, the executive secretary shall furnish the required application form and instructions for obtaining a licensed irrigator's or licensed installer's certificate of registration.

§423.7. APPLICATION AND EXAMINATION FEES; FORM OF PAYMENT.

Persons applying for an irrigator's certificate of registration shall remit an application and examination fee of $75. Persons applying for an installer's certificate of registration shall remit an application and examination fee of $35. Payments shall be made by personal check, money order, or cashier's check made payable to the Texas Board of Irrigators. These fees shall not be refundable.

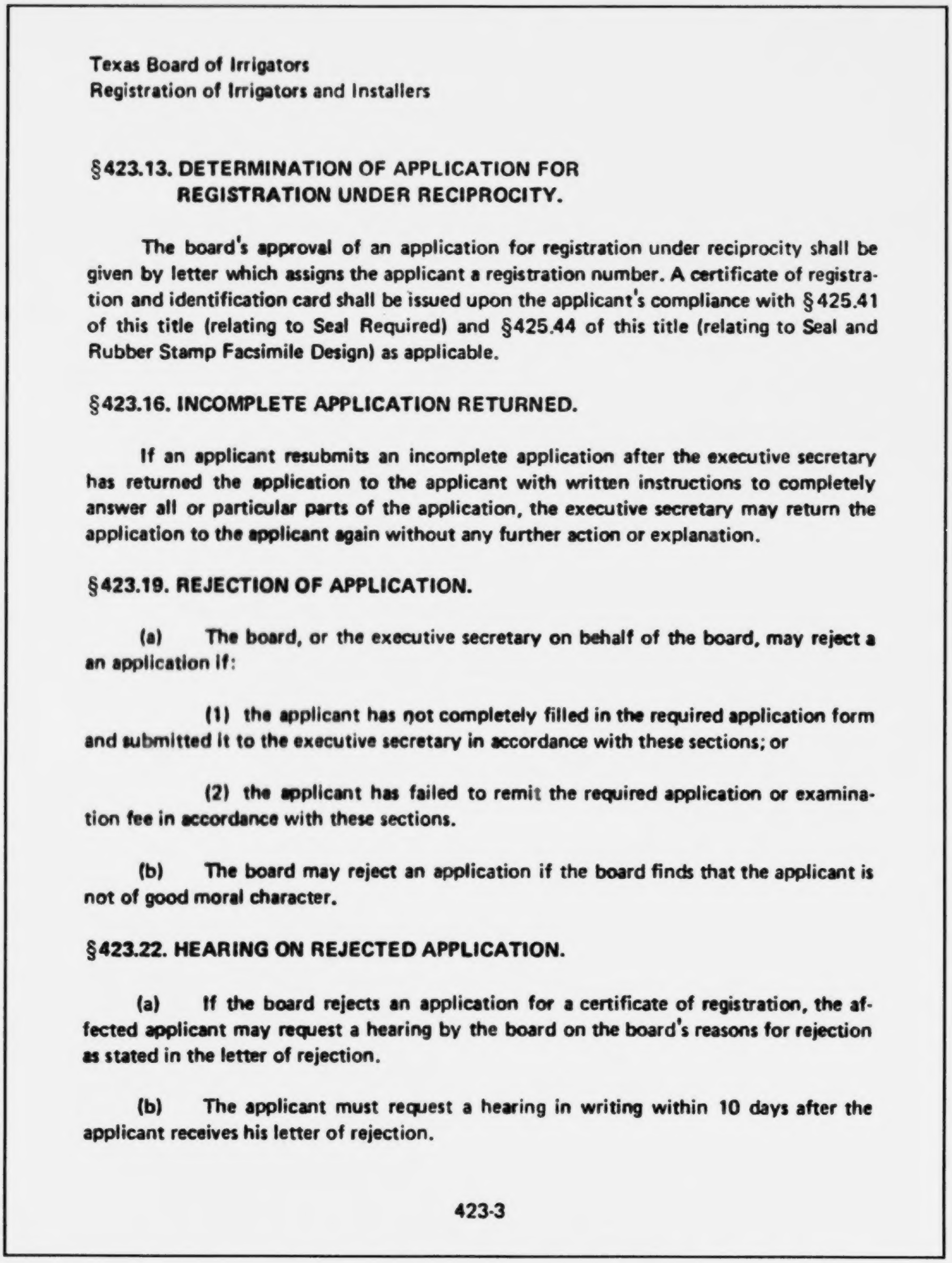
§423.10. APPLICATION PROCESSING.

(a) Applications for registration shall be submitted to the board in a complete form and accompanied by the required application or examination fee, as applicable.

(b) Applications for registration by examination may be made at any time but must be accompanied by the examination fee and received by the executive secretary at least 30 days prior to the applicant's examination date. Applicants shall be responsible for fulfilling application requirements by the deadline.

(c) The board shall verify and evaluate each submitted application, and if the board or the executive secretary should require additional relevant information, the applicant shall submit such information within the time and form requested.

(d) Rejection of an application for registration shall be by letter sent by certified mail to the applicant explaining the board's reasons for rejection, outlining the procedures under which reconsideration may be possible, and explaining the applicant's right to a hearing.



Texas Board of Irrigators
Registration of Irrigators and Installers

§423.13. DETERMINATION OF APPLICATION FOR REGISTRATION UNDER RECIPROCITY.

The board's approval of an application for registration under reciprocity shall be given by letter which assigns the applicant a registration number. A certificate of registration and identification card shall be issued upon the applicant's compliance with §425.41 of this title (relating to Seal Required) and §425.44 of this title (relating to Seal and Rubber Stamp Facsimile Design) as applicable.

§423.16. INCOMPLETE APPLICATION RETURNED.

If an applicant resubmits an incomplete application after the executive secretary has returned the application to the applicant with written instructions to completely answer all or particular parts of the application, the executive secretary may return the application to the applicant again without any further action or explanation.

§423.19. REJECTION OF APPLICATION.

(a) The board, or the executive secretary on behalf of the board, may reject a an application if:

(1) the applicant has not completely filled in the required application form and submitted it to the executive secretary in accordance with these sections; or

(2) the applicant has failed to remit the required application or examination fee in accordance with these sections.

(b) The board may reject an application if the board finds that the applicant is not of good moral character.

§423.22. HEARING ON REJECTED APPLICATION.

(a) If the board rejects an application for a certificate of registration, the affected applicant may request a hearing by the board on the board's reasons for rejection as stated in the letter of rejection.

(b) The applicant must request a hearing in writing within 10 days after the applicant receives his letter of rejection.

Texas Board of Irrigators
Registration of Irrigators and Installers

(c) The board shall hold its hearing on the reasons for rejection after it receives the written request for the hearing.

(d) During the hearing, the board shall consider any relevant evidence and argument presented by the applicant in support of his application.

(e) The board shall inform the applicant of its final decision on his application by certified mail. If the final decision is to uphold its rejection of the application, the board shall state in its final decision the reasons and relevant facts for rejection.

Texas Board of Irrigators
Registration of Irrigators and Installers

EXAMINATIONS
§§423.41-423.62

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§423.41. ELIGIBILITY FOR WRITTEN EXAMINATIONS.

The board, or any board members, or the executive secretary on behalf of the board shall administer written examinations only to persons who the board has determined to be of good moral character and who have completed the required application form and have submitted it and the required examination fee to the executive secretary in accordance with these sections.

§423.44. NOTIFICATION OF EXAMINATION DATE, TIME, AND PLACE.

The executive secretary shall notify each person eligible to take the written examination of his examination date, time, and place by first-class mail.

§423.47. STUDY MATERIALS.

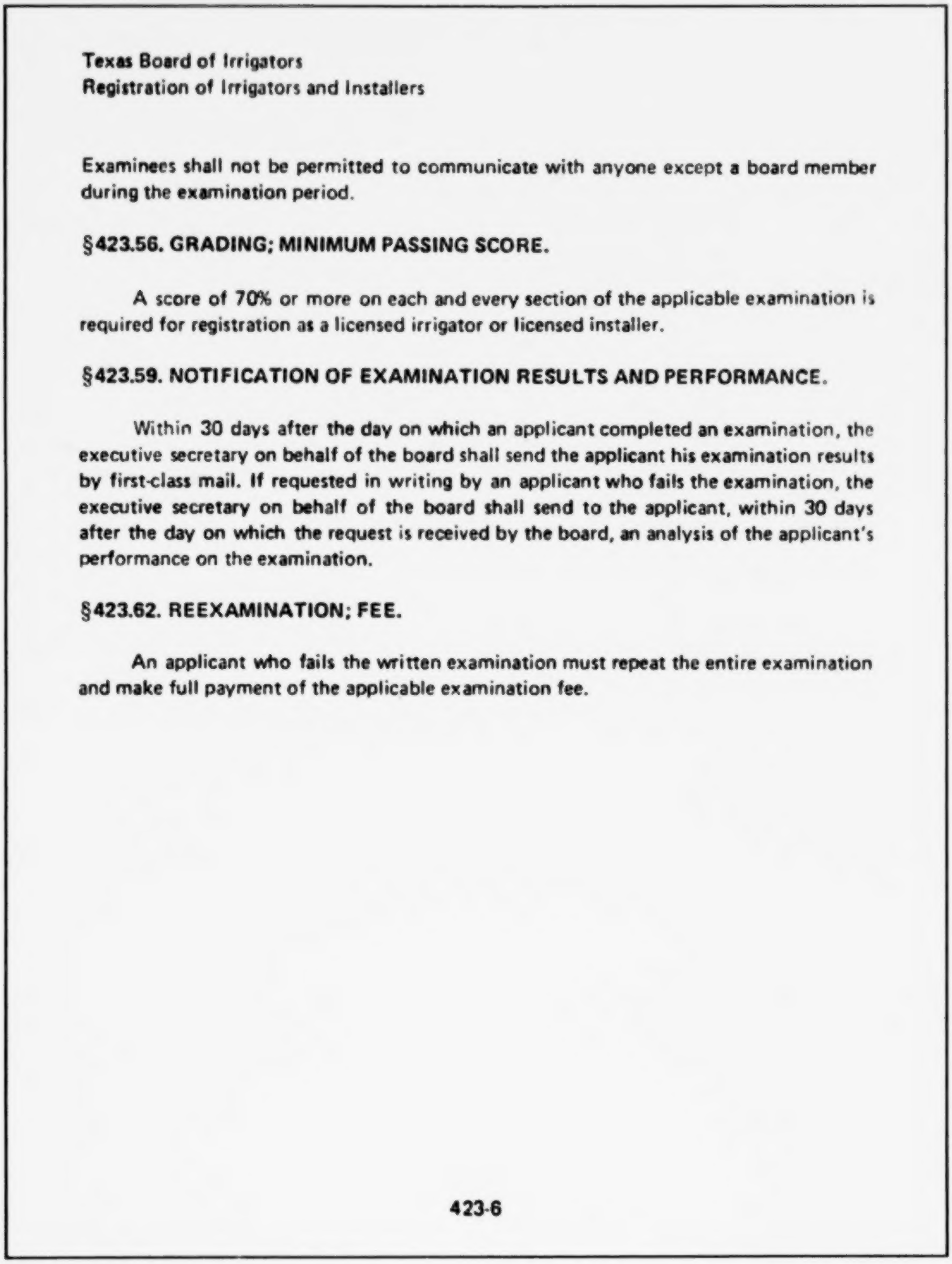
Upon request, the executive secretary shall furnish information regarding study materials to persons eligible to take the written examination.

§423.50. APPEARANCE FOR EXAMINATION; FAILURE TO APPEAR.

Applicants shall personally appear for the written examination at the designated date, time, and place and be prepared to present sufficient identification. An applicant who fails to appear for an examination shall forfeit the required examination fee except upon written request showing good cause why the applicant failed to appear, as determined by the board.

§423.53. EXAMINATION CONDITIONS.

Examinations shall be conducted under conditions assuring honest results. The executive secretary, individual board members, or their designees shall monitor all tests.



Examinees shall not be permitted to communicate with anyone except a board member during the examination period.

§423.56. GRADING; MINIMUM PASSING SCORE.

A score of 70% or more on each and every section of the applicable examination is required for registration as a licensed irrigator or licensed installer.

§423.59. NOTIFICATION OF EXAMINATION RESULTS AND PERFORMANCE.

Within 30 days after the day on which an applicant completed an examination, the executive secretary on behalf of the board shall send the applicant his examination results by first-class mail. If requested in writing by an applicant who fails the examination, the executive secretary on behalf of the board shall send to the applicant, within 30 days after the day on which the request is received by the board, an analysis of the applicant's performance on the examination.

§423.62. REEXAMINATION; FEE.

An applicant who fails the written examination must repeat the entire examination and make full payment of the applicable examination fee.

Texas Board of Irrigators
Certificate of Registration and Seal

CERTIFICATE OF REGISTRATION
§§425.1-425.25

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§425.1. ISSUANCE OF CERTIFICATE; REGISTRATION FEE.

(a) Once the board has determined that an applicant has passed the board's written examination, and the applicant has paid to the executive secretary the registration fee in accordance with subsection (b) of this section and has complied with §425.41 of this title (relating to Seal Required) and §425.44 of this title (relating to Seal and Rubber Stamp Facsimile Design) as applicable, the executive secretary shall issue a certificate of registration and identification card to the applicant.

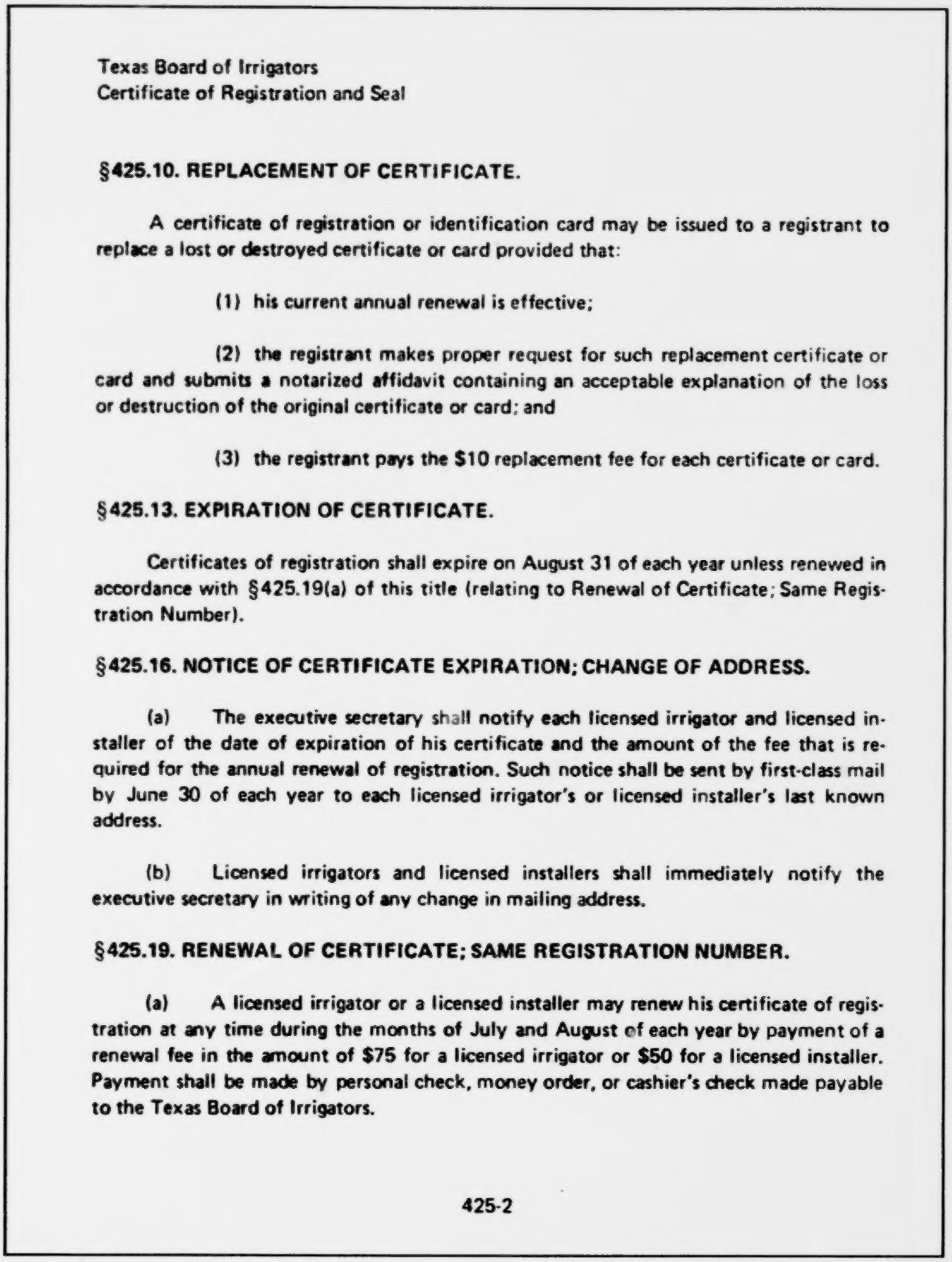
(b) The registration fee shall be the applicable amount specified in §425.19 of this title (relating to Renewal of Certificate; Same Registration Number) prorated on a monthly basis beginning with the month during which the board informed the applicant that he passed the examination through the following August. Payment of the fee shall be made within 60 days after the date of the letter sent by the executive secretary to the applicant, notifying him of the amount of the fee. Payment shall be made by personal check, money order, or cashier's check made payable to the Texas Board of Irrigators.

§425.4. DESCRIPTION OF CERTIFICATE.

Certificates of registration shall identify the registrant by name and registration number, show effective date and year, confirm the registrant's qualifications, and acknowledge the registrant as a licensed irrigator or licensed installer.

§425.7. DISPLAY OF CERTIFICATE.

Every person holding a certificate of registration shall display it at his place of business or employment and be prepared to substantiate his annual renewal for the current year.



Texas Board of Irrigators
Certificate of Registration and Seal

§425.10. REPLACEMENT OF CERTIFICATE.

A certificate of registration or identification card may be issued to a registrant to replace a lost or destroyed certificate or card provided that:

(1) his current annual renewal is effective;

(2) the registrant makes proper request for such replacement certificate or card and submits a notarized affidavit containing an acceptable explanation of the loss or destruction of the original certificate or card; and

(3) the registrant pays the $10 replacement fee for each certificate or card.

§425.13. EXPIRATION OF CERTIFICATE.

Certificates of registration shall expire on August 31 of each year unless renewed in accordance with §425.19(a) of this title (relating to Renewal of Certificate; Same Registration Number).

§425.16. NOTICE OF CERTIFICATE EXPIRATION; CHANGE OF ADDRESS.

(a) The executive secretary shall notify each licensed irrigator and licensed installer of the date of expiration of his certificate and the amount of the fee that is required for the annual renewal of registration. Such notice shall be sent by first-class mail by June 30 of each year to each licensed irrigator's or licensed installer's last known address.

(b) Licensed irrigators and licensed installers shall immediately notify the executive secretary in writing of any change in mailing address.

§425.19. RENEWAL OF CERTIFICATE; SAME REGISTRATION NUMBER.

(a) A licensed irrigator or a licensed installer may renew his certificate of registration at any time during the months of July and August of each year by payment of a renewal fee in the amount of $75 for a licensed irrigator or $50 for a licensed installer. Payment shall be made by personal check, money order, or cashier's check made payable to the Texas Board of Irrigators.

(b) Renewal of a certificate of registration shall be effected by issuance of a current identification card. Each identification card shall show the name of the registrant, the card's expiration date and the number of the certificate of registration which it renews.

§425.22. FAILURE TO RENEW CERTIFICATE OF REGISTRATION; NOTICE; PENALTY.

(a) Failure of a licensed irrigator or a licensed installer to renew his certificate of registration by August 31 of each year does not deprive him of the right to renewal, but his registration shall be automatically suspended and the fee paid for renewal of a certificate of registration after the August 31 deadline shall be increased 10% for each month or part of a month that the renewal payment is delayed. If the licensed irrigator or licensed installer fails to pay his renewal fee within 90 days after the August 31 deadline, his registration shall automatically expire and he must requalify under Texas Civil Statutes, Article 8751, §8, and must comply with Chapter 423 of this title (relating to Registration of Irrigators and Installers) to obtain a licensed irrigator or licensed installer certificate of registration.

(b) The executive secretary shall immediately notify each licensed irrigator and licensed installer who has failed to renew his certificate of registration by August 31 of such failure by certified mail sent to his last known address.

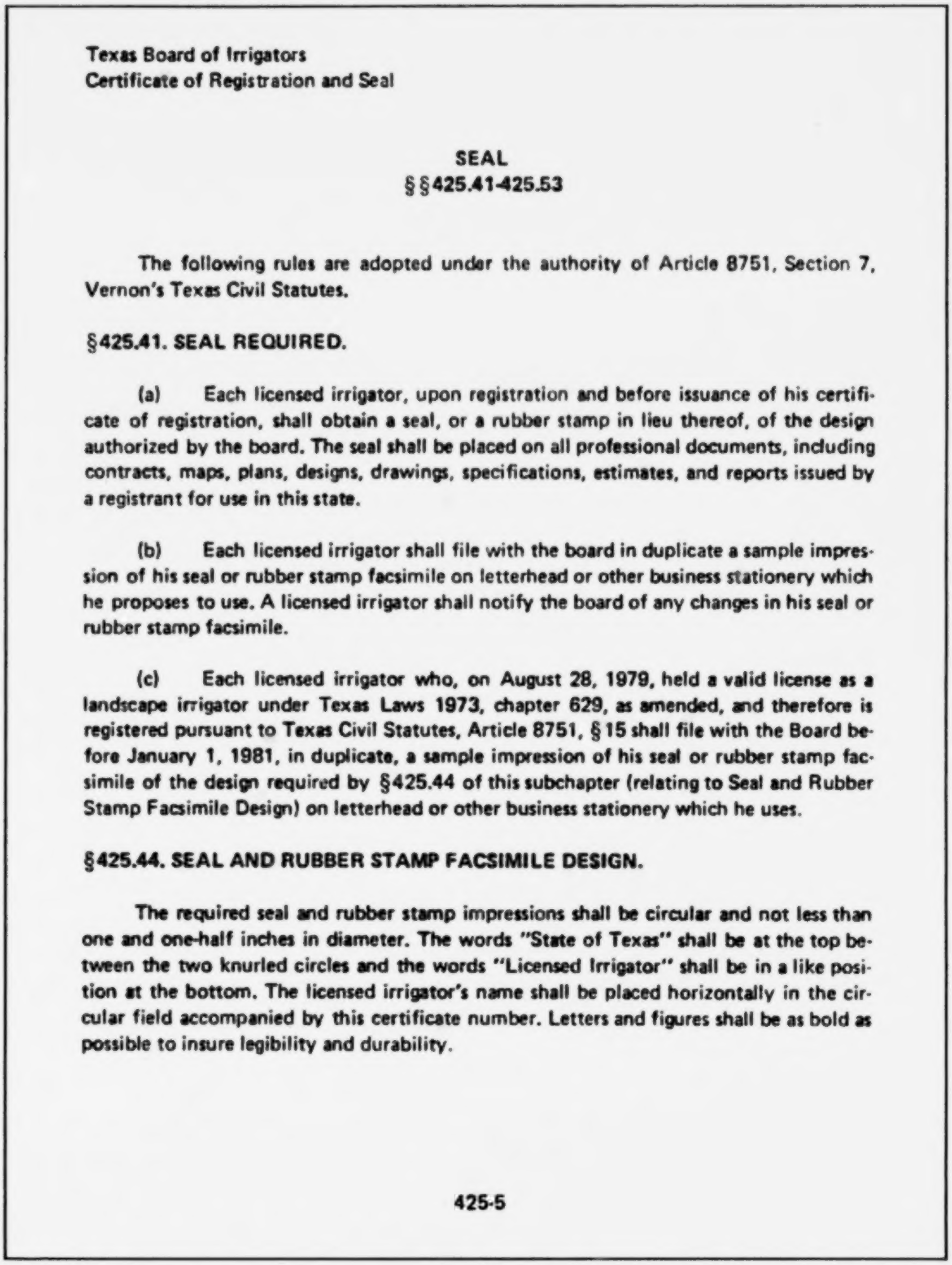
(c) Any irrigator or installer who acts as a licensed irrigator or licensed installer when his registration has been automatically suspended or has automatically expired pursuant to these sections is in violation of Texas Civil Statutes, Article 8751 and is subject to the penalties provided in section 12 thereof.

§425.25. UNAUTHORIZED USE OF CERTIFICATE.

(a) Only a licensed irrigator or licensed installer may use or attempt to use his certificate of registration.

(b) Anyone who uses or attempts to use as his own the certificate of registration of someone else who is a licensed irrigator or licensed installer violates Texas Civil Statutes, Article 8751 and this section.

(c) Any licensed irrigator or licensed installer who authorizes anyone else to use his certificate of registration to act as a licensed irrigator or licensed installer violates this section.



Texas Board of Irrigators
Certificate of Registration and Seal

SEAL
§§425.41-425.53

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§425.41. SEAL REQUIRED.

(a) Each licensed irrigator, upon registration and before issuance of his certificate of registration, shall obtain a seal, or a rubber stamp in lieu thereof, of the design authorized by the board. The seal shall be placed on all professional documents, including contracts, maps, plans, designs, drawings, specifications, estimates, and reports issued by a registrant for use in this state.

(b) Each licensed irrigator shall file with the board in duplicate a sample impression of his seal or rubber stamp facsimile on letterhead or other business stationery which he proposes to use. A licensed irrigator shall notify the board of any changes in his seal or rubber stamp facsimile.

(c) Each licensed irrigator who, on August 28, 1979, held a valid license as a landscape irrigator under Texas Laws 1973, chapter 629, as amended, and therefore is registered pursuant to Texas Civil Statutes, Article 8751, § 15 shall file with the Board before January 1, 1981, in duplicate, a sample impression of his seal or rubber stamp facsimile of the design required by §425.44 of this subchapter (relating to Seal and Rubber Stamp Facsimile Design) on letterhead or other business stationery which he uses.

§425.44. SEAL AND RUBBER STAMP FACSIMILE DESIGN.

The required seal and rubber stamp impressions shall be circular and not less than one and one-half inches in diameter. The words "State of Texas" shall be at the top between the two knurled circles and the words "Licensed Irrigator" shall be in a like position at the bottom. The licensed irrigator's name shall be placed horizontally in the circular field accompanied by this certificate number. Letters and figures shall be as bold as possible to insure legibility and durability.

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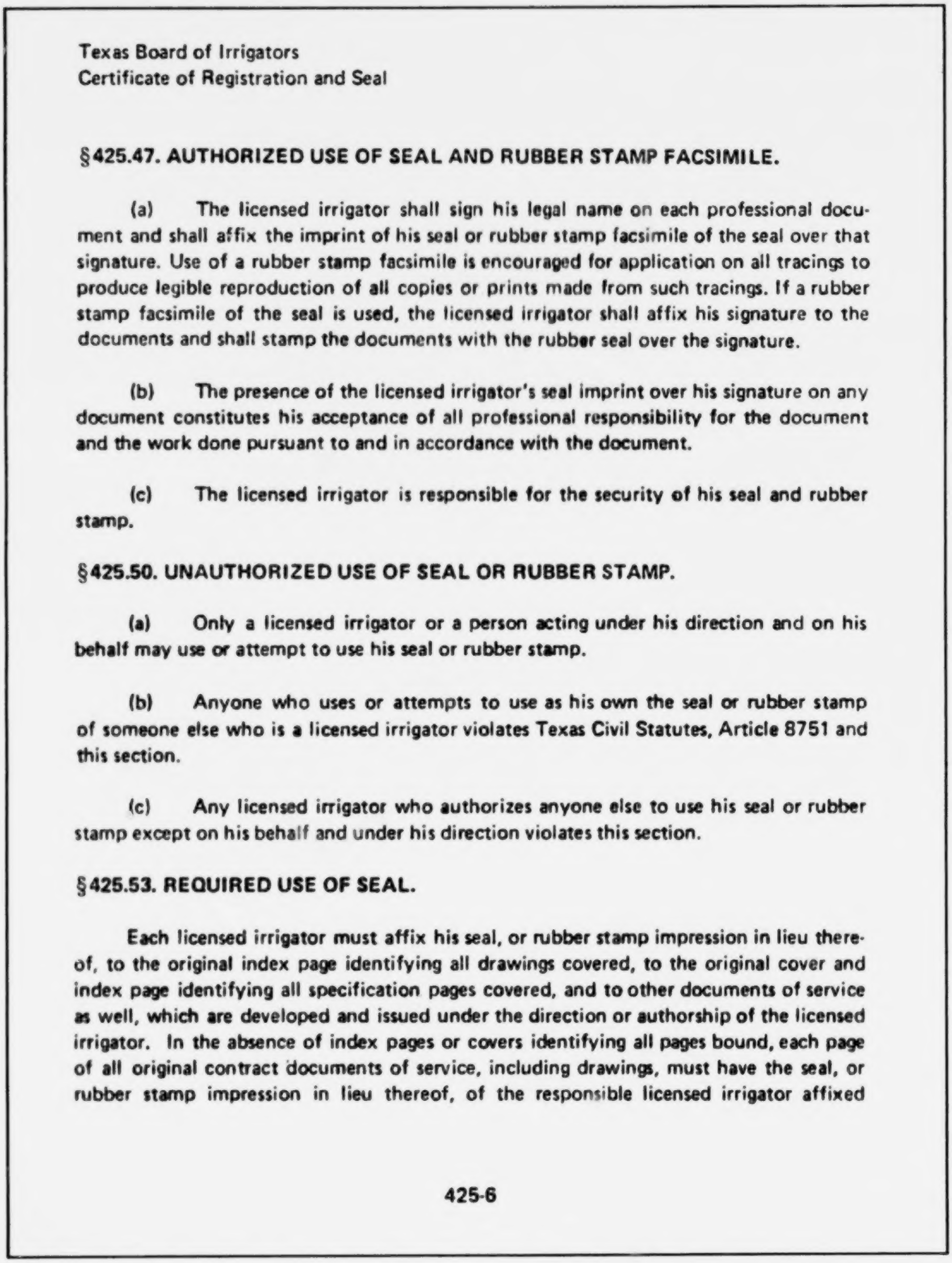

Texas Board of Irrigators
Certificate of Registration and Seal

§425.47. AUTHORIZED USE OF SEAL AND RUBBER STAMP FACSIMILE.

(a) The licensed irrigator shall sign his legal name on each professional document and shall affix the imprint of his seal or rubber stamp facsimile of the seal over that signature. Use of a rubber stamp facsimile is encouraged for application on all tracings to produce legible reproduction of all copies or prints made from such tracings. If a rubber stamp facsimile of the seal is used, the licensed irrigator shall affix his signature to the documents and shall stamp the documents with the rubber seal over the signature.

(b) The presence of the licensed irrigator's seal imprint over his signature on any document constitutes his acceptance of all professional responsibility for the document and the work done pursuant to and in accordance with the document.

(c) The licensed irrigator is responsible for the security of his seal and rubber stamp.

§425.50. UNAUTHORIZED USE OF SEAL OR RUBBER STAMP.

(a) Only a licensed irrigator or a person acting under his direction and on his behalf may use or attempt to use his seal or rubber stamp.

(b) Anyone who uses or attempts to use as his own the seal or rubber stamp of someone else who is a licensed irrigator violates Texas Civil Statutes, Article 8751 and this section.

(c) Any licensed irrigator who authorizes anyone else to use his seal or rubber stamp except on his behalf and under his direction violates this section.

§425.53. REQUIRED USE OF SEAL.

Each licensed irrigator must affix his seal, or rubber stamp impression in lieu thereof, to the original index page identifying all drawings covered, to the original cover and index page identifying all specification pages covered, and to other documents of service as well, which are developed and issued under the direction or authorship of the licensed irrigator. In the absence of index pages or covers identifying all pages bound, each page of all original contract documents of service, including drawings, must have the seal, or rubber stamp impression in lieu thereof, of the responsible licensed irrigator affixed

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thereto. The absence of a seal or rubber stamp impression affixed to any contract documents or plans is a violation of this section.

Texas Board of Irrigators
Water Supply Connections

STANDARDS FOR CONNECTIONS TO POTABLE WATER SUPPLIES
§§427.1-427.10

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§427.1. LOCAL REGULATION.

Where any city, town, county, special purpose district, or other political subdivision of the state requires licensed irrigators or licensed installers to comply with reasonable inspection requirements or ordinances or regulations designed to protect the public water supply, any of which relates to work performed or to be performed within such political subdivision's territory by licensed irrigators or licensed installers, a licensed irrigator or licensed installer shall comply with such requirements, ordinances, and regulations.

§427.4. ABSENCE OF LOCAL REGULATION–BACKFLOW PREVENTION DEVICES.

Where a licensed irrigator's or a licensed installer's connection of an irrigation system or yard sprinkler system to a public or a private potable water supply is not subject to any inspection requirement, ordinance, or regulation of any city, town, county, special purpose district, or other political subdivision of the state, the licensed irrigator or licensed installer making such connection shall install one of the following devices:

(1) Vacuum breakers. Vacuum breakers are designed to prevent only back-syphonage. Therefore, vacuum breakers shall not be used in systems where back-pressure may occur. In this subchapter, back-pressure means any pressure, regardless of its source, against the outlet side of the backflow prevention device, which exceeds the supply pressure against the inlet side of the device. Where vacuum breakers may be used, they shall be installed at least 12 inches above the surrounding ground.

(2) Atmospheric vacuum breakers. In addition to the prohibition and installation requirements of subsection (a) of this section, continuous pressure on the supply side of an atmospheric vacuum breaker is prohibited. Therefore, atmospheric vacuum breakers shall be installed in either of the two following ways:

Texas Board of Irrigators
Water Supply Connections

(a) A separate atmospheric vacuum breaker shall be installed on the discharge side of each water control valve, between the valve and all of the sprinkler heads such valve controls.

(b) A single atmospheric vacuum breaker may be installed in the pressure main only if there is a single, automatic master water control valve in the pressure main. The automatic master water control valve shall be installed between the water supply and the atmospheric vacuum breaker.

(3) Pressure-type vacuum breaker. Subject to the prohibition and installation requirements of subsection (a) of this section, a single pressure-type vacuum breaker may be used in systems where the sprinkler main may be pressurized at all times.

(4) Double check assembly backflow preventor. A double check assembly (DCA) backflow preventor may be used where water supply pressure and back pressure on the device may continuously exist.

(5) Reduced pressure principle device. A reduced pressure principle device shall be installed above ground in a location so as to insure that the device will not be submerged during operation. In addition, adequate provisions shall be made for any water which may be discharged through the device's release valve. A licensed irrigator may not incorporate this device in an irrigation system design without first obtaining informed approval to do so from the party for whom he is designing the system.

§427.10. CONNECTIONS TO ALTERNATIVE WATER SUPPLIES.

(a) Because of the danger of contaminating potable water supplies, the design and installation of irrigation systems and yard sprinkler systems which incorporate connections to alternate potable and nonpotable water supplies are not recommended and are discouraged unless absolutely necessary.

(b) Where an irrigation system or yard sprinkler system is designed to have alternate water supplies, one being a potable water supply and the other a nonpotable water supply, a licensed irrigator or licensed installer shall not install any connection for alternate potable and nonpotable water supplies except one which:

(1) provides for a complete absence of pipe between the two water supplies (i.e., air gap);

(2) makes impossible the connection of the two water supplies to each other; and

(3) makes impossible the simultaneous connection of both water supplies to the irrigation system or yard sprinkler system.

(c) The installation of any mechanical connection device as a substitute for or equivalent of the connection required by subsection (b) of this section is prohibited and is a violation of this section.

Texas Board of Irrigators
Violation of Statute or Board Rules

COMPLAINT PROCESS
§§429.1-429.22

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§429.1. COMPLAINT.

(a) Any person knowledgeable of any probable violation of Texas Civil Statutes, Article 8751 or of these sections may file a written complaint with the board.

(b) Any person knowledgeable of any probable act of a licensed irrigator or licensed installer which may constitute gross negligence, incompetency, or misconduct while he is acting as a licensed irrigator or licensed installer may file a written complaint with the board.

(c) A written complaint shall include the name and address of the person against whom the complaint is filed and the alleged facts and shall be notarized.

§429.4. BOARD'S RECEIPT OF COMPLAINT.

Upon the board's receipt of a complaint, the executive secretary shall:

(1) send three copies of the complaint to the executive director;

(2) send one copy of the complaint by certified mail to the respondent; and

(3) send a copy of the complaint to the chairman of the board.

§429.7. INVESTIGATION OF COMPLAINT.

(a) The chairman of the board may appoint not more than three members of the board to investigate a complaint. The chairman may appoint one or more licensed irrigators to assist board members in the investigation of a complaint.

(b) The executive secretary shall furnish each appointed board member with a copy of the complaint file.

(c) Appointed members shall investigate the matters complained of and may take steps to secure the respondent's voluntary compliance with Texas Civil Statutes, Article 8751 and these sections, or otherwise informally resolve the matter.

(d) Upon completion of the investigation, the investigating board members shall file with the executive secretary a written report, including a detailed description of the investigation and any informal resolution, and any recommendations to the board. The report shall be signed by at least one of the board members investigating the complaint.

(e) Upon receipt of the investigation report, the executive secretary shall send, by first-class mail, copies of the report to the complainant and respondent, notifying them of the deadline for filing written responses to the report. The executive secretary shall also send a copy of the report to the chairman of the board.

(f) Any response of the complainant or respondent to the investigation report must be in writing and filed with the executive secretary within 14 days after the executive secretary mailed copies of the report to the complainant and respondent.

(g) Upon receipt of a response to an investigation report, the executive secretary shall send copies of the response to the chairman of the board and the board members investigating the complaint.

§429.10. INFORMAL RESOLUTION OF COMPLAINT.

Where the chairman of the board determines that a complaint is informally resolved:

(1) The executive secretary shall so inform the complainant and respondent in writing, notifying them that the board will take no further action on the complaint unless requested to do so by the complainant; and

(2) The board members investigating the complaint shall brief the board, at its next meeting, on the complaint, investigation and resolution.

§429.13. SETTING COMPLAINT ON BOARD AGENDA; NOTICE.

Where the chairman of the board determines that a complaint is not informally resolved, he may place consideration of the complaint on the agenda for a board meeting.

The executive secretary shall send notice of the meeting to the complainant and respondent by first-class mail, and to the executive director.

§429.16. BOARD CONSIDERATION OF COMPLAINT; BOARD ACTION ON COMPLAINT.

(a) During its consideration of a complaint, the board shall hear any relevant evidence and argument presented on behalf of the complainant and the respondent.

(b) After hearing relevant evidence and argument, the board may consider whether the information presented in the complaint and at its meeting is sufficient to warrant further action by the commission, the executive director, or the attorney general. If the board considers such information sufficient, it shall issue an order referring the complaint to the commission, or request the executive director or the attorney general, or both, to take appropriate measures to enforce Texas Civil Statutes, Article 8751 and the board's rules. If the board considers the information insufficient to warrant further action by the commission, executive director or attorney general, it may take any action it deems appropriate.

(c) The executive secretary shall notify the complainant and respondent of any decision or action of the board by letter sent by first-class mail.

§429.19. COPIES OF BOARD ORDER.

Where the board enters an order referring a complaint to the commission, the executive secretary shall issue the order by filing copies with the commission and the executive director and sending copies by certified mail to the complainant and the respondent.

§429.22. PROBABLE VIOLATION REPORT OF BOARD MEMBER.

(a) Where a member of the board becomes aware of a probable violation of Texas Civil Statutes, Article 8751 or of these sections, such member may file a written report with the board, setting forth the name of the person about whom the report is filed and the facts pertaining to the probable violation.

Texas Board of Irrigators
Violation of Statute or Board Rules

(b) A board member's report of a probable violation shall be processed by the board pursuant to §§429.1, 429.4, 429.7, 429.10, 429.13, 429.16, and 429.19 of this title (relating to Complaint Process) and this section.

ENFORCEMENT
§§429.51-429.55

The following rules are adopted under the authority of Article 8751, Section 7, Vernon's Texas Civil Statutes.

§429.51. Civil Penalty.

(a) A person who violates Texas Civil Statutes, Article 8751; a rule adopted by the board pursuant to Article 8751; or an order of the commission issued after a hearing, pursuant to Article 8751, §5(c); and/or an order revoking a certificate of registration under Article 8751, §11, is subject to a civil penalty of not to exceed $1,000.00 for each offense. Each day a violation is committed is a separate offense.

(b) An action to recover the penalty under subsection (a) of this section may be brought by the board in any court of competent jurisdiction in the county in which the offending activity occurred, in which the defendant resides, or in Travis County.

§429.53. Injunctions.

The board may enforce Texas Civil Statutes, Article 8751, a board rule, or commission order by injections or other appropriate remedy. The action may be brought by the board in a court of competent jurisdiction in the county in which the offending activity occurred, in which the defendant resides, or in Travis County.

§429.55. Action By Attorney General.

At the request of the board, the attorney general shall institute and conduct a suit in the name of the state to recover the civil penalty as provided under §429.51 of this title (relating to Civil Penalty) or for injunctive relief or other appropriate remedy or for both.

Texas Board of Irrigators
Licensed Irrigator Standards

LICENSED IRRIGATOR STANDARDS
§§431.1-431.7

The new sections are adopted under Texas Civil Statutes, Article 8751, Section 7, which provides the Texas Board of Irrigators with the authority to adopt rules consistent with the Act.

§431.1. PURPOSE OF STANDARDS.

(a) The correct practice of irrigation as a profession is essential for the protection and conservation of the water resoucres of the state. The installation of irrigation systems should be conducted by individuals with high ethical standards. The Legislature has vested in the Texas Board of Irrigators the authority and duty to establish and enforce standards of professional conduct and ethics for practitioners of the irrigation industry. These standards of conduct have been adopted by the Texas Board of Irrigators to ensure compliance with and enforcement of the statutory charge to the board.

(b) Every applicant for registration as a licensed irrigator shall become fully informed of the obligations and responsibilities inherent in the practice of irrigation as outlined by these Standards of Conduct. Each licensed irrigator shall be deemed to have notice of these Standards of Conduct, and shall be required to abide by the standards.

§431.2. INTENT.

(a) These Standards of Conduct are established to prescribe responsibility and knowledge on the part of the irrigator and to aid in governing the irrigation industry.

(b) The board shall determine what actions constitute violations of the Standards and institute appropriate disciplinary action which may lead to the suspension or revocation of a license in accordance with the applicable state statutes.

§431.3. PROFICIENCY IN FIELD OF IRRIGATION; REPRESENTATION OF QUALIFICATIONS.

(a) Competence in the performance of services of a licensed irrigator requires that the licensee's knowledge and skill encompass the currently accepted practice and knowledge of selling, designing, consulting, installing, maintaining, altering, repairing, or servicing an irrigation system including the connection of such system in and to a private or public, raw or potable water supply system or any water supply. Licensed irrigators must therefore maintain proficiency in the field of irrigation.

(b) A licensed irrigator shall accurately and truthfully represent to a prospective client his qualifications and capabilities of resources to perform the services requested and shall not perform services for which he is not qualified by experience or knowledge in the technical field involved.

§431.4. ADVERTISEMENT.

(a) A licensed irrigator shall display his registration number in the form of "LI _______" in block letters at least two inches high, on both sides of all vehicles used by him or by his employees for installation, service or repair of irrigation systems.

(b) All advertisements, including business cards, of a licensed irrigator shall display his registration number in the form of "LI _______".

§431.5. CONTRACTS.

(a) A licensed irrigator's agreement to install an irrigation system, if in writing, shall specify his name, business address and telephone number, date that the agreement was signed by each party thereto, total agreed price, and the design number or a copy of the design. If there is no written design, the agreement shall contain a brief description of the major components of the system to be installed.

(b) All written contracts to install irrigation systems shall include the statement: "Irrigation in Texas is regulated by the Texas Board of Irrigators, P.O. Box 12337, Austin, Texas 78711, (512) 463-7990."

§431.6. DESIGN.

(a) No licensed irrigator may design an irrigation system, or a portion thereof, so as to require the use of any component part in a way which exceeds the manufacturer's performance limitations for the part, unless the use is necessary to accommodate special site conditions. Special site conditions shall be noted on the design or in the written agreement if there is no written design.

(b) Adequate design and specifications of an irrigation system to be installed are the responsibility of the licensed irrigator who designs or supervises the designing of the system regardless of whether a fee is collected for the design work.

(c) The design shall include a statement of area coverage of the irrigation system, and any system which does not provide 100% coverage shall be so noted on the design or in the agreement if there is no written design.

§431.7. WARRANTIES.

On all installations of new irrigation systems (i.e., excluding remodeling and renovation) a licensed irrigator shall present the customer a written statement of his guarantees for materials and labor furnished in the installation of the irrigation system.

Appendix C - Examples of Local Codes

The following examples show how greatly local irrigation/plumbing codes can vary from city to city across Texas.

City	Backflow Device Req.	Location of Device	Type of Box	Tie in Req.
Amarillo	DCA (must be 24" below ground)	Between water meter and sprinkler system	Not specified	Schedule 40 or better PVC
Canyon	Atmospheric vacuum breaker A DCA may be substituted	Not specified	Not specified	Galvanized steel, Type K copper, or Schedule 40 PVC
Dallas	AVB or PVB (if a DCA is used, it must be 12" deep with 12" gravel below)	Any place in yard	Large concrete or Turf area plastic	Match existing service
Euless	DCA	Out of city easement	Standard	Copper
Houston	Pressure vacuum breaker	At cross connection point	Not applicable	Match existing service (cannot increase pipe size without a plumbing permit)
Richardson	DCA	On private property	Plastic or concrete	No compression fittings permitted

(This page included for duplexing.)

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COMMON TERMINOLOGY OF THE TURF IRRIGATION INDUSTRY

As semantics is always a problem when dealing with areas all over this and other nations, the use of the following list of terms is explained as the terms are used in this manual. These terms and meanings are generally accepted as standards within the irrigation industry.

ABS	Acrylonitrile butadiene styrene.
ABS pipe	Black, semi-rigid plastic pipe; limited in irrigation usage. Utilizes solvent welded fittings.
Absorption rate	The rate at which a soil will absorb water. It is not a static rate as it incorporates the infiltration rate and the infiltration capacity of the soil.
Angle valve	A valve from which water flows out at a 90 degree plane from the plane at which it enters.
Anti-siphon device	A device to protect domestic water from possibly contaminated water in sprinkler system lines. Also called a vacuum breaker.
Application rate	The rate at which water is applied to the turf by the sprinklers in pattern.
Arc	The degrees of coverage of a sprinkler from one side of throw to the other. A 90 degree arc would be a quarter circle sprinkler.
Architect scale	A device that expresses foot measurements in parts of an inch. Ex: 1/4" = 1'0". A measuring scale.
As-built-plan	A finished plan of an installed irrigation system designating valve, sprinkler and controller locations, routing of pipe and control lines and all other pertinent information.
Atmospheric vacuum breaker	An anti-siphon device which uses a floating seat to direct water flow. Water draining back from irrigation lines is directed to the atmosphere to protect domestic water supply.
Automatic control valve	A valve in a sprinkler system which is activated by an automatic controller by way of control lines.
Automatic drain valve	A valve that opens automatically when pressure drops within a sprinkler line so that water remaining in the line will drain.
Automatic system	An irrigation system which will water in accordance to a pre-set program decided upon, and programmed, into the automatic controllers.

Available pressure	Pressure of water in a pipe measured when there is a flow condition.
AWWA	Abbreviation for American Water Works Association.
Backflow	Water which drains back, or is sucked back, from irrigation lines. Contamination of this water by insecticides, herbicides, fungicides, fertilizers, and bacteria is possible.
Backflow prevention device	A device which prevents backflowing water from irrigation lines, possibly contaminated, from mixing with domestic water supplies.
Bellied pipe	Pipe enlarged at one end to accept the spigot end of another piece of pipe.
Block (of heads)	A section of sprinklers controlled by one valve.
Block system	An irrigation system in which several groups of sprinklers are controlled by one valve for each group.
Body (of head)	The exterior case or shell of the sprinkler.
Booster pump	A pump which has a pressurized suction and is designed to raise the existing pressure of the water in the irrigation main.
Bubbler head	A sprinkler head that sprinkles water rather than spraying it. Bubblers are normally used in very small planting areas, or to water the root system of a tree.
Bushing	The method of adapting a fitting to either a larger or smaller size.
Bush down	To use a bushing to go from a large pipe to a smaller one.
Bush up	To use a bushing to go from a small pipe to a larger one.
By-pass-valve	A pressure relief valve in a pumping station which opens when pumping pressures rise, dumping excess water back into the reservoir, eliminating repetitive on-off cycles of the pumps.
CI	Universal abbreviation for cast iron pipe.
CTS	Universal abbreviation for copper tube size.
CU	Universal abbreviation for copper.
Cam drive	A method of rotating a sprinkler stream by the collision of two solid pieces of material.

Cancel switch	Also called a rain switch. A means of overriding the watering cycle of a controller without interrupting future watering programs.
Cap	A fitting that either threads or is solvent welded onto a pipe to prevent flow.
Channel locks	A type of plier. Also called a slip-joint plier. Used because of its ability to grasp pipe tightly.
Check valve	A valve which permits water to flow in one direction only.
Class (of pipe)	A method by which pipe is grouped according to the working pressure at which it can be used. Class 160 pipe can be used where pressures don't exceed 160 P.S.I., etc.
Compression fitting	A fitting that is secured by the compression of a rubber ring caused by the snug threading of its end caps.
Control lines	Lines which transmit information from the controller to the valves.
Control wires	The wires which transmit the signals to open and close form the automatic controller to the automatic valves.
Controller	The timing mechanism and its mounting box. The controller signals the automatic valves to open and close on a pre-set program.
Coupling	A fitting used to join two pieces of pipe together.
Coupler key	A hollow shaft to which a sprinkler or hose can be attached and which is inserted into a quick coupling valve, causing the valve to open and provide water.
Coverage	Coverage can relate the actual throw of water from a head to the recommended throw, or the efficiency of water application to an irrigated area.
Cross	A four-way fitting.
Cross connection	Any connection made between a domestic or potable water supply and a potential source of contamination or pollution.
Cycle	Refers to one complete run of a controller through all programmed controller stations.
Design	To recommend the use of sprinkler system components which make up the total system. A design can be an informal field plot location or a formal hydraulically engineered drawing.

Diaphragm	The portion of an automatic valve which regulates the passage of water through the valve.
Direct burial wire	Plastic coated single strand copper wire for use as a control line for electric valves.
Distribution	The manner in which a sprinkler applies water to the irrigated area.
Distribution curve (of sprinkler head)	A curve showing the rate of water application by a sprinkler at various points along the radius.
Distribution pattern	The pattern of water application by a sprinkler over the area the sprinkler covers. Usually applied to sprinklers in pattern.
Domestic water	Water meant for human consumption. Potable, or drinking water.
Double check valve	A backflow prevention device employed in irrigation systems.
Drain valve	A valve used to drain water from a line. It can be a manual drain valve in mains or laterals or an automatic drain valve in nonpressurized lines.
DRI splice	Trade name for a waterproof splicing device
Dual programming	The feature on some automatic controllers which allows two diverse watering schedules.
Dump valve	A valve pre-set to open at a certain pressure to prevent damage to a sprinkler system caused from excess pumping pressure.
Electronic valve	Automatic valves usually controlled by a 24-30 volt current carried in direct burial ground wire between the controller and valves.
Electrolysis	A chemical reaction caused by the joining of two dissimilar metals.
Engineers' scale	A device that expresses foot measurements as a certain number of feet per inch. Ex: 1" = 10'0".
Elevation gain	Pressure gained as water is used downhill from its source. It is figured at the rate of .433 pounds per square inch for each foot of elevation.
Elevation loss	Pressure lost as water is used uphill from its source.
Evapotranspiration	The rate at which water is evaporated into the air and absorbed into the soil

FIP	Abbreviation for threads. Female Iron Pipe.
Female adapter	A fitting with a slip socket on one end and a female threaded socket on the other.
Field capacity	The amount of water a layer of soil will hold before the water continues to move down.
Flow	The movement of water.
Flow control valve	A valve which is pre-set and remains constant.
Flow restriction	Physical restriction in the lines of water flow.
Flux	A chemical oxidizer used in soldering a connection in copper.
Foot-head	A measurement of pressure. Equivalent to .433 pounds per square inch and equal to one foot of elevation.
Friction loss	That loss incurred when water is moving through an enclosure.
GPH	The universal abbreviation for gallons per hour. The standard for flow measurement of water in drip irrigation.
GPM	Abbreviation for gallons per minute.
Gate valve	A valve utilizing a rising and descending gate to control the flow of water. Gate valves are normally used as a mainline shut-off valve rather than as a sprinkler section or zone valve because they wear quickly with heavy use.
Gauge (wire)	A standard used in wire sizing. The larger the gauge number, the smaller the wire in diameter.
Gear driven	A method of rotating a sprinkler stream utilizing a series of reduction gears to facilitate smooth rotation.
Glove valve	A valve through which water flows in the inlet, up through the sealing and flow control opening and out the outlet.
Grid	A cross-hatched pattern printed on some drafting paper that disappears when reproduced. Usually printed in standard scales.
Head	A sprinkler head.
Head to head spacing	Spacing of sprinklers so that the radius of the sprinklers match the spacing of them.

Hose bibb	The valve to which a garden hose attaches. Also called a hose faucet. Hose threads are spaced further apart than standard IPS threads.
Hose thread	The type of thread used on garden hoses. It is a different thread than the standard iron pipe size threads so that it can be quickly attached to an outlet.
Hydraulics	The study of liquid movement and its dynamics.
Hydraulic ram	The shock wave caused by filling a pipe with water at a faster rate than air can escape.
Hydraulic system	A sprinkler system that utilizes water as a replacement for electric current to open and close valves.
Hydraulically controlled	An automatic valve which is controlled by the controller supplying and releasing water under pressure to the diaphragm or piston of the valve through use of control tubing.
ID	Universal abbreviation for inside or interior diameter of pipe.
IPS	Universal abbreviation for iron pipe size.
Impact or impulse drive	The method of providing rotational movement to a sprinkler head by utilizing a weighted or spring loaded arm that is repulsed by the water stream, and upon returning, collides with the head, forcing movement.
In-pattern	Refers to the precipitation rates of sprinklers when their throws overlap.
Insert fittings	Fittings designed to be pushed inside of a pipe. Usually barbed and secured with stainless steel clamps. Normally used on polyethylene pipe.
Isolate	A method of rendering a portion of a looped sprinkler mainline inoperative so that repairs can be made without rendering the system useless.
Lateral	A field or section pipe line other than the main pressure line. This line is pressurized when the controller actuates the section valve.
Loop	A piping method which allows water to circulate without end.
Main	A pipe sized to carry the water for the irrigation system from source to section valve. This line may stand under constant pressure when the system is inoperative.

Male adapter	A fitting with a slip socket at one end and a male threaded end on the other.
Manual drain valve	A manual valve, usually a boiler drain, used to drain the water from a main line prior to a freeze or for repairs.
Manual system	A system in which control valves are opened manually.
Master valve	A valve installed at the supply point of the main which controls water flow into the system.
MIP	Abbreviation for Male Iron Pipe threads.
Moisture control	An automatic feature on some controllers that allows the system to come on only if the moisture content of the soil is correct.
Multi-cycling	Many short watering cycles rather than one long cycle. Helps to eliminate run-off and flooding.
Non-pressure lines	See lateral.
Normally closed valve	An automatic valve through which no water will flow unless external influences are applied to cause the valve to open.
Normally open valve	An automatic valve through which water will flow unless external influences are applied to close the valve.
NSF	Abbreviation for National Sanitation Foundation.
Nozzle	A device through which sprinkler system water is channeled to form the desired pattern and radius.
OD	The universal abbreviation for outside diameter or dimension in pipe.
Operating cycle	One complete run by a controller through all of its active stations.
Operating pressure	The pressure at which a system or sprinkler operates.
Orifice	The opening in a nozzle through which water is forced. Its size determines radius and pattern.
Overlap	The amount one sprinkler pattern overlaps another.
Over watering	Applying more water than necessary to turf or plantings.
PE	Universal abbreviation for Polyethylene.
P.S.I.	Abbreviation for pounds per square inch.

P.V.C. Pipe	Unplasticized polyvinyl chloride pipe.
PE pipe	Black, flexible plastic pipe.
Pen-tite connectors	Trade name for a waterproof wire splicing device.
Percolation	The penetration of soil by water. The rate of percolation is affected by the type of soil, slope of terrain, run-off, etc.
Pipe wrench	A tool expressly designed for holding pipe.
Piston	(1) The portion of an automatic valve which regulates the passage of water through the valve. (2) The portion of a pop-up sprinkler head that is pushed up when water pressure is applied.
Plug	A fitting that goes into pipe or fittings to stop the flow of water.
Potable water	Water which is meant for human consumption. It can be used for irrigation systems as long as protection is provided to prevent contamination to the domestic supply.
Pressure	The force of water, measured in PSI or foot-head.
Pressure loss	The loss of pressure under flow conditions caused by friction of water passing through a closure.
Pressure rating	A rating of pipe for given pressures.
Pressure regulator	A device which regulates available pressure to a pre-set maximum under static or flow condition.
Pressure relief valve	A valve which will open when the pressure exceeds a preset point.
Pressure vacuum breaker	A backflow prevention device which incorporates the use of a spring loaded seat for positive sealing to protect domestic water from possibly contaminated irrigation water.
Program	The watering schedule of an automatic sprinkler.
Programming	The act of planning and entering the watering program into the automatic controller.
Pump circuit	The feature on some automatic controllers which allows a connection to be made with the pump starter of the pump so that the starter will be energized when the watering cycle begins. May also activate a master valve.

Quick coupling system	A sprinkler system which uses quick coupling valves, keys and impact heads. The valves are permanently installed with the keys and sprinklers manually moved from valve to valve.
Quick coupling valve	The valve used in a quick coupling system which is activated by a coupling key.
Rain switch	(1) A feature on many controllers which lets the owner stop watering during rainy periods without interrupting the program. (2) A device which will automatically cancel watering when a pre-set amount of rain occurs.
Remote control valve	An automatic valve which opens or closes when energized by a controller.
Riser	(1) A threaded nipple to which a sprinkler is attached. (2) A tall nipple used to water over shrubs or ground cover.
Run-off	Water which is not absorbed by the ground to which it is applied. Caused by water being applied at too rapid a rate, watering for too long a period of time, or by a slope.
SDR	Abbreviation for Standard Dimension Ratio. The SDR is a nominal or approximately equal measurement of pipe.
Saddle	A type of fitting which goes over the pipe. A hole is drilled through the pipe to furnish water to the outlet of the saddle.
Scale	A device that converts feet to fractions of an inch for reduction purposes in designing. Ex: Architects scale, engineers scale.
Scale drawing	A miniature drawing of a large object.
Section (noun)	A group of sprinkler heads which operate from one valve.
Section (verb)	The act of placing certain sprinkler heads within a section in the design phase.
Sleeve (conduit)	A pipe placed under a sidewalk or driveway that is large enough to permit the passage of active sprinkler pipes or wiring.
Sleeve (valve)	Any protective device that allows access to a section valve. A sleeve can be a short length of large diameter pipe, with or without cap, or a manufactured valve box.
Slip fitting	A type of fitting that is solvent welded on PVC or ABS pipe.

Snaking pipe	The practice of undulating pipe from side to side in the bottom of a trench to counteract expansion and contraction breakages.
Socket	The belled end of a piece of pipe or the slip end of a PVC or ABS fitting.
Solder	An alloy of lead and tin that melts at a relatively low temperature and sets as soon as it cools. Solder is used to join copper fittings in a sprinkler system.
Solenoid	The solenoid is the device on an automatic electric valve that permits the flow of water into the upper chamber of a valve, permitting it to open or close. It is a simple electromagnet.
Solvent	A material which causes a partial dissolving of PVC or ABS pipe and fittings so that a chemical fusion can be accomplished between the pipe and fitting.
Solvent welding	The act of chemically fusing pipe and fittings together using solvent.
Spacing	The distance between sprinkler heads.
Spigot	The end of a piece of pipe; not the bellied end.
Spring check valve	A valve that utilizes a spring loaded seat to permit water to flow in one direction only.
Sprinkler	The sprinkler head.
Static pressure	The pressure of water when it is not moving.
Station	(1) A position on the controller that is responsible for a particular valve or section. (2) A group of sprinkler heads, a section or zone.
Stop and waste valve	A valve required by most cities so that property owners can shut off all water to the house. They are usually located near the house or, in cold climates, may be inside.
Strap wrench	A wrench used in piping that utilizes a canvas trap to grip the pipe.
Supply (water)	The origin of water used in a sprinkler system.
Surge	An energy wave in pipe lines caused by sudden opening or closing of valves.
Sweated fittings	A fitting that has been connected utilizing a soldered joint.

Swing check valve	A valve which allows water to flow in only one direction, using a flexible hinge and the weight of water to seat.
Swing joint	A threaded connection between the pipe and sprinkler which allows movement to be taken up in the threads rather than as a sheer force on the pipe. Also used to raise or lower sprinklers to final grade.
Tee	A fitting that permits pipe to be connected at a 90 degree angle from itself on one side only. It is shaped like the letter "T".
Thermal expansion	The expansion or contraction of pipe due to differences in temperature.
Threaded fitting	A fitting which has threads to receive the standard pipe thread.
Torch	A device used to heat copper prior to the application of solder on a sweated joint, usually utilizing either propane or acetylene as a fuel source.
Underspaced	Heads spaced too close together, resulting in over watering and wet spots.
Uniformity of application	A general term designating how uniform the application of the sprinkler is over the area it is covering while in pattern.
Vacuum breaker	See atmospheric or pressure vacuum breaker.
Valve	A device that controls the flow of water.
Valve-in-head	Indicates that the automatic control valve is part of the sprinkler.
Velocity (of water)	The speed at which water travels. Usually expressed in FPS (feet per second).
Water demand	The amount of water, measured in GPMs, that is expended through the sprinkler heads when operating.
Water hammer	A shock wave created by a fast closing valve.
Water pressure	Pressure which water exerts, measured in pounds per square inch or in foot-head.
Water ram	A shock wave that occurs when water at high pressure is introduced into an air filled pipe. Since the air cannot escape, a pulsating wave is created which exceeds the pressure of the water entering the pipe.

Watering requirements	The irrigation or water requirements of the area to be covered, based on variables of season, types of plantings, and available demand.
Watering time	The length of time a station or section of heads remains on.
Wetting front	The leading edge of water as it moves down.
Wire nut	A device that insulates a wire splice by threading onto two twisted wires.
Working pressure	Actual pressure taken at any given point when a sprinkler system is operating. Usually taken at the base of a sprinkler head.
Wye strainer	A strainer that resembles the letter "Y" in its configuration. It utilizes a wire or nylon mesh strainer to strain foreign particles out of water.
Xeriscape	Optimized vegetation, water use, and landscape arrangement.

STANDARD "DESIGNATION CODES" FOR PRESSURE RATED PLASTIC PIPES:

1120—PVC pipe, Type one, Grade one, 2000 psi hydrostatic design stress.

1220—PVC pipe, Type one, Grade two, 2000 psi hydrostatic design stress.

2110—PVC pipe, Type two, Grade one, 1000 psi hydrostatic design stress.

2306—Polyethylene pipe, Type two, Grade three, 600 psi design stress.